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# SOME OBSERVATIONS ON THE GROWTH OF ORGANISMS IN WATER PIPES.

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[*Read Sept.* 8, 1897.]

The reactions between the water and the water pipes of any water works system are topics of vital importance. They involve such matters as iron rusting, tuberculations, lead poisoning, and others, all of which have been the subject of much study, and some of which are even now but imperfectly understood. Up to the present time, it has been the chemical and physical reactions that have received attention. There is, however, a sort of biological reaction between the water and its conductors which is not unworthy of our consideration.

The question may be approached from two sides. In fact, there are two questions, namely: What effect have the aqueducts and pipes upon the biology of the water, and what effect has the water upon the biology of the aqueducts and pipes? There is comparatively little accurate data to be obtained upon these questions, and as the extensive biological observations of the Boston Water Works, now covering a period of eight years, offer the greatest amount of available material,* they will be used as the basis of the discussion.

*Annual Reports of the Boston Water Works, 1891 to 1895.

It is unnecessary to describe this water supply to the members of this Association, but for the sake of those not familiar with it, it may be well to state that there are two different sources, Lake Cochituate and the Sudbury River. Both are surface waters. The former is a chain of lakes, four miles in length and of considerable depth, that furnishes water light in color, at times rich in microscopical organisms, and containing moderate numbers of bacteria. This is conveyed through a brick-lined aqueduct to the distributing reservoirs at Chestnut Hill and Brookline. The Sudbury River, utilized by the construction of several storage reservoirs, or basins, furnishes a water of rather high color, and one that contains an abundance of organic matter. This water also is conveyed to the Chestnut Hill and Brookline reservoirs, where it mixes with the Cochituate water. From these reservoirs the mixed waters are carried to the city through several lines of 48-inch and 36-inch pipes.

It was the custom, for a number of years, to collect weekly samples of water for analysis at the effluent gate houses of these two reservoirs, at a tap in Park Square, Boston, and at a tap in Mattapan. Occasional samples were taken at other places in the city. The object was to determine the difference in the character of the water in the different sections of the city, and to ascertain what changes took place in the water during its passage through the pipes. The tap in Park Square is about five miles from the Chestnut Hill reservoir, and the tap in Mattapan about eleven miles. Examination of the pipe lines, and a study of the color of the water, show that in all probability the Park Square tap is supplied with water direct from the Chestnut Hill reservoir, while at Mattapan the water comes largely from the Brookline reservoir. This is largely a matter of assumption, however, and as the Superintendent has always taken great pains to keep the mixture of Sudbury and Cochituate water the same in both reservoirs, it matters little for the purposes of this paper whether the water comes from the one or the other. Hence we may say that the chief difference between the two tap samples lies in the different lengths of pipe through which the water passes. It should be borne in mind, however, that as the water flows from the reservoirs to the outer limits of the distribution system, the sizes of the pipes diminish, so that the Mattapan water passes through a greater length of pipe of small size than the water at Park Square.

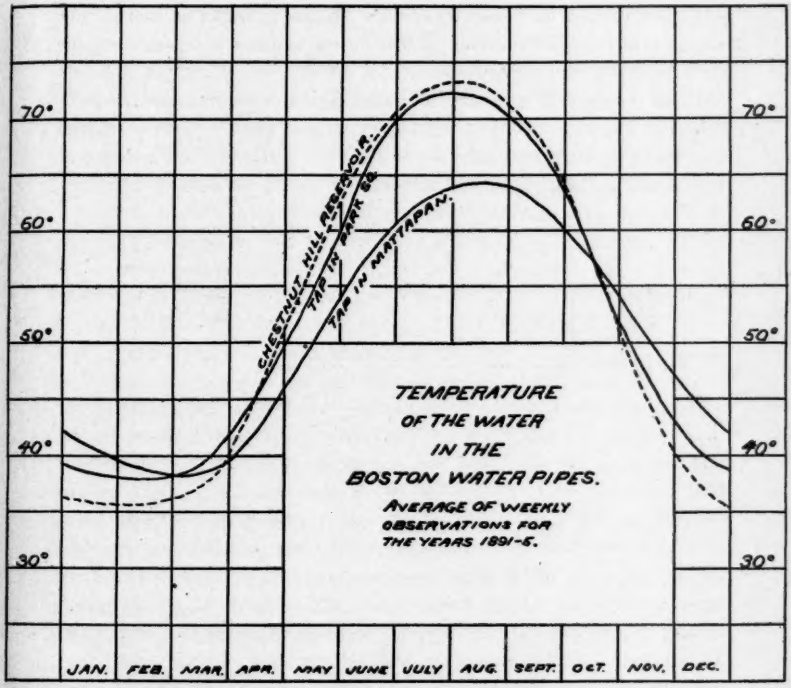



PLATE I.

The temperature of the water at the effluent gate house at Chestnut Hill reservoir, and at the taps mentioned, is shown on Plate I, where the curves represent the averages of weekly observations for five years (1891 to 1895). As would be expected, the greatest range of temperature occurs in the reservoir, though the water in the tap in Park Square agrees with it closely. The effect of the passage of the water through the pipes is well shown by the curves. During the spring and summer the water grows cooler, and during the fall and winter it grows warmer as it passes through the ground. In the summer the water is always several degrees cooler at Mattapan than at Park Square, the greatest difference being observed during July and August. In the winter the minimum temperature at the two taps is about the same, but at Park Square the lowest

point is reached in February, while at Mattapan it is found one month later. A comparison of the mean monthly temperatures for each year is given in Table I.

If we consider the results of the biological examinations, as published in the annual reports of the Boston Water Works, we shall find that for the five years from 1891 to 1895, the microscopical organisms and amorphous matter were present, as follows:

| | Number of Standard Units per c. c. | |
|---|---|---|
| | Organisms. | Amorphous Matter. |
| Chestnut Hill reservoir, gate house | 248 | 209 |
| Brookline reservoir, gate house | 215 | 212 |
| Tap in Park Square | 194 | 190 |
| Tap in Mattapan | 84 | 105 |

If we assume that the water at the Park Square tap comes from the Chestnut Hill reservoir, and that at the Mattapan tap from Brookline reservoir, we shall find that during its passage from Chestnut Hill reservoir to Park Square the water lost 22 per cent. of its organisms and 9 per cent. of its amorphous matter; while from Brookline reservoir to Mattapan it lost 61 per cent. of its organisms and 50 per cent. of its amorphous matter. If we assume that both taps receive the mixed water from both reservoirs, we find that during its passage through about five miles of pipes the water lost 16 per cent. of its organisms and 10 per cent. of its amorphous matter; and through eight miles of pipe, 64 per cent. of its organisms and 50 per cent. of its amorphous matter. The greater part of the reduction is seen to occur not near the reservoirs where the pipes are large and the currents great, but in the extremities of the distribution system, where the pipes are smaller. It will be sufficient and somewhat simpler to consider only the two taps.

Tables II. and III. show the number of microscopical organisms and the amount of amorphous matter in the water at Park Square and Mattapan for each month during a period of five years. The figures are based on weekly examinations. The averages for the whole period are given in the last two columns. The latter are also shown graphically on Plate II. Study of the plate and tables shows that during the winter, when there are comparatively few organisms in the water, the reduction in the pipes is much less than during the summer, when organisms are more abundant. We find by

calculation that during the six months of the year, from November to April, there is a reduction of 44 per cent. in organisms and 24 per cent. in amorphous matter in passing through about six miles of pipe; while during the six months from May to October the reduction is 62 per cent. for the organisms and 53 per cent. for the amorphous matter. It is interesting to note that the reduction in organisms is greater than the reduction in amorphous matter.

Not only are the microscopical organisms and amorphous matter reduced in the pipes, but the bacteria also tend to decrease. This fact has been observed several times in other cities. The figures presented in Table IV. show that in the pipes of the Boston Water Works the decrease does not occur throughout the entire year. In the summer, when the temperature of the water is high and when the organisms in the water and those growing in the pipes are passing rapidly through stages of growth and decay, there is a considerable increase. This is seen best by the aid of the diagram (Plate II.). That it is no accidental observation is shown by the fact that it occurs regularly each year, and that the same results were obtained whether the samples were plated at the time of collection or after transportation to the laboratory.

In order to determine what organisms showed the greatest reduction in the pipes, a more detailed study of the examinations was made for the years 1892 and 1893. The following were the results:

PERCENTAGE REDUCTION OF MICROSCOPICAL ORGANISMS IN THE DISTRIBUTION PIPES BETWEEN PARK SQUARE AND MATTAPAN.

| | Average for the years 1892 and 1893. |
|---|---|
| Diatomaceæ | 58 per cent. |
| Chlorophyceæ | 57 " " |
| Cyanophyceæ | 54 " " |
| Infusoria | 64 " " |
| Miscellaneous | 58 " " |
| Organisms of all kinds | 56 " " |

It appears that the infusoria are reduced the most and the cyanophyceæ the least. The difference between the two is slight, however.

Examinations of the Mystic water supply at College Hill reservoir and at a tap in Chelsea also show a reduction in organisms and amorphous matter during the passage of the water through the

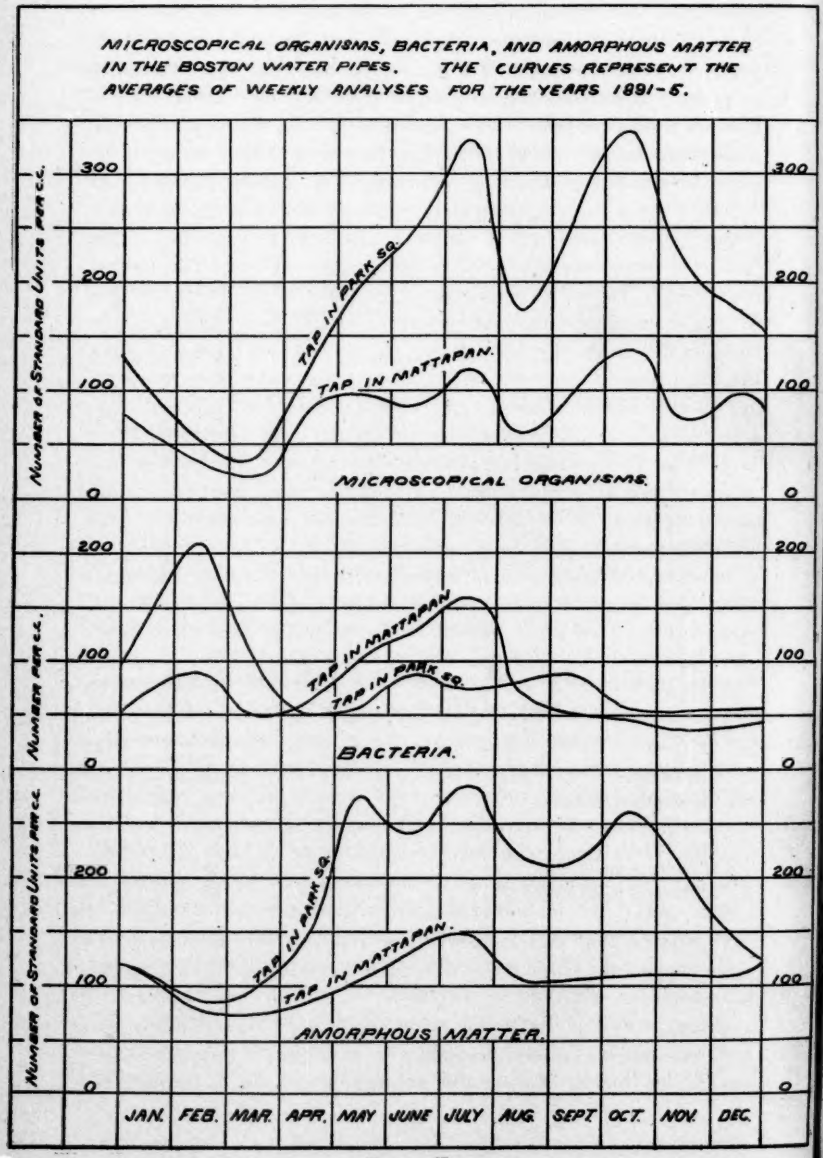

MICROSCOPICAL ORGANISMS, BACTERIA, AND AMORPHOUS MATTER IN THE BOSTON WATER PIPES. THE CURVES REPRESENT THE AVERAGES OF WEEKLY ANALYSES FOR THE YEARS 1891-5.
NUMBER OF STANDARD UNITS PER C.C.
300
200
100
0
TAP IN PARK SQ.
TAP IN MATTAPAN.
MICROSCOPICAL ORGANISMS.
NUMBER PER C.C.
200
100
0
TAP IN MATTAPAN
TAP IN PARK SQ.
BACTERIA.
NUMBER OF STANDARD UNITS PER C.C.
200
100
0
TAP IN PARK SQ.
TAP IN MATTAPAN.
AMORPHOUS MATTER.
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

PLATE II.

pipes. Table V, which represents the results of monthly examinations for four years, shows that the average reduction of organisms was 41 per cent. and of amorphous matter, 52 per cent. The bacteria were usually lower at the tap, but occasionally an increase in the pipes was noticed.

Questions naturally arise as to the cause and effect of this reduction of organisms in the pipes. We may consider them under the following topics: sedimentation, disintegration, decomposition, and consumption by other organisms.

Most, and probably all, of the microscopical organisms are heavier than water. Some always settle in quiet water, and they do so in the pipes whenever the current is reduced to a certain point. Others, which in ponds usually rise to the surface on account of the gas bubbles which they contain, will settle in the pipes when the pressure of the water has deprived them of their gas. In dead ends the organisms and particles of amorphous matter often accumulate and form deposits upon the bottom of the pipes. They also tend to deposit on up-grades. It is a matter of frequent observation that the water from the high points of a distribution system contains fewer organisms than that from the low points. The same fact has been observed in high buildings, where the difference between the water on the upper stories and that on the lower floor is often considerable.

Many of the common organisms are very fragile. Even a slight agitation of the water will break them up. This is particularly true of certain infusoria. It is easy to understand, then, how the subjection to the pressure and the currents of a distribution system causes them to go to pieces. No better example can be found than the Uroglena. A cluster of delicate organisms, embedded in a gelatinous material, upon the outer surface of a sphere, it is one of the most fragile organisms imaginable. A slight pressure or agitation will rupture the colony, and scatter and disintegrate the individuals. In the epidemics of Uroglena that have afflicted so many of our New England ponds, it has been found almost invariably that the Uroglena were abundant in the water of the reservoir, but not in the tap water. By their disintegration the oil globules, which are the cause of the vile fishy odor, are liberated, with the result that the water at the tap almost always smells and tastes worse than the water at the source. This disintegration, with

liberation of oil globules, occurs to some extent in organisms that could hardly be called fragile. The diatoms, which have siliceous cell walls, sometimes go to pieces in the pipes, causing an increase in the odor of the water. This was observed in the recent epidemic of Asterionella in Brooklyn, N. Y.

The organisms found in surface waters are accustomed to live in the light. When they enter the dark pipes they are liable to die and decompose. This is particularly true of some of the organisms that are abundant in the summer. Microscopical examination of samples from the service taps have often revealed organisms in a decomposing condition, swarming with bacteria. This decomposition tends to reduce the numbers of organisms in the pipes.

Another important consideration in the reduction of organisms is the fact that in many of the distribution systems where surface waters are used the pipes are covered with growths of sponge, etc. These attached growths depend for their food material upon the minute organisms found in the water. If the growths are abundant, the removal of organisms from the water from this cause may be considerable. This naturally brings us to our second topic,—the growth of organisms in the pipes.

Comparatively little has been written about the subject in this country. Our attention has been called to growths of Crenothrix and of Fresh Water Sponge, but no attempt has been made to give an accurate account of the organisms infesting the distribution systems of our water supplies. In Europe, however, we find that the subject has been considered to some extent.

In the city of Hamburg the "Minute animals inhabiting water pipes were studied by Hartwig Petersen* in 1876. Ten years later Karl Kraepelin† made a more extended study. His observations are of much interest. He found an animal growth, often more than one centimetre thick, covering the entire surface of the pipes. The composition of this growth varied in different places. He gives a list of sixty different species observed. In many places the walls of the pipes were covered with fresh water sponges, chiefly Spongilla fluviatilis and S. lacustris. Mollusks were conspicuous, especially

*Hartwig Petersen, "Die Bewohner der Hamburger Wasser-leitung," in Vehandl. d. Vereins f. Natur. Unterhaltung. II. Bd., Hamburg, 1876.

†Karl Kraepelin, "Die Fauna der Hamburger Wasser-leitung," Abhandl. d. Naturw. Vereins in Hamburg. IX. Bd., Heft. I., 1886.

the mussel Dreyssena polymorpha. Snails were also numerous. Hundreds of "water lice" (Asellus aquaticus) and "water crabs" (Gammarus pulex) were found at every examination. The material known as "Pipe moss" was common, and consisted largely of Cordylophora lacustris and the Bryozoa Plumatella and Paludicella.

At the time when Crenothrix was giving so much trouble at Rotterdam, Hugo de Vries* made an extended study of the animals and plants found in the water pipes of that city. His observations were confined chiefly to the pipes and canals which conveyed the unfiltered water of the River Maas to the filter beds. In speaking of one of the canals he says, "The walls were thickly covered with living organisms up to the water level. They formed an almost continuous coating of changing composition. There were only one or two exceptions to this. In one place, where the water came from the pumps with great velocity, the walls were free from living organisms; and in another place, where there was almost no current, only one living form was seen. There was one section of one of the canals, where a gentle current was flowing, that was a magnificent aquarium. The walls were everywhere covered with white tufts of fresh water sponge (Spongilla fluviatilis.) Many of these tufts reached a diameter of six or eight inches, but most were somewhat smaller than that. Between the sponge patches were seated countless numbers of the mussel Dreyssena polymorpha. Individuals old and young were often seen grouped together in colonies which sometimes extended completely over the sponges. But what most of all attracted attention was a luxurious growth of the "Horn-polyp," Cordylophora lacustris. It covered the mussel shells and occupied all the space between the sponges. The stalks reached a length of an inch or more. On and between the Cordylophora swarmed countless numbers of Vorticella, Acineta, and other infusoria and rotifers. These organisms had no lack of food material and the absence of light protected them from many foes which, in the light, thin out their ranks. Over all these animals Crenothrix was found growing in abundance. The shells of the mussels and the stems of the "Horn-polyps" were coated with a thick felt-like layer of these iron bacteria." In other localities in the pipes the place of the

*Hugo de Vries, "Die Pflanzen und Thiere in dem dunkelln Raumen der Rotterdamer Wasser-leitung." Jena, 1890.

"Horn-polyps was occupied by the Bryozoa, or "Moss animalcules." All of these branching forms were spoken of collectively by the workmen as "Pipe moss."

In the summer of 1896, when the pipes of the Metropolitan Water Works were being laid in Beacon street, near the Chestnut Hill reservoir, a 16-inch main leading from the Fisher Hill reservoir to the Brighton district was opened. This afforded an opportunity to examine the material on the inside of a pipe that had been laid ten years. Inspection showed that besides the usual coating of iron rust, tubercles, etc., there were numerous patches of fresh water sponge (both Spongilla and Meyenia), brownish or almost white in color, and about the size of the palm of one's hand. What was most conspicuous, however, was a sort of brown matting which covered much larger areas, and which had a thickness of about $\frac{1}{4}$ inch. It had a very rough surface and, when dried, reminded one of a piece of coarse burlap. This proved to be an animal form belonging to the Polyzoa, and known as Fredericella. As fragments of it had several times before been observed in the water from the service taps, and as it had been seen growing in some small pipes connected with the filtration experiments at Chestnut Hill reservoir, more extended observations were made in different parts of the distribution system.

These brought out the fact that sponges and Polyzoa are well established in the pipes. Many other kinds of organisms were also observed. In some places almost pure cultures of Stentor and Zoothamnium were found. At other points hosts of different organisms were seen, such as snails, mussels, Hydra, Nais and Anguillula, Acineta, Vorticella, countless numbers of ciliated infusoria; Arcella, Amœba, and many other forms. The growths were distinctly animal in their nature, though in many cases parasitic vegetable forms such as Achlya, Crenothrix, Leptothrix, etc., were common. The most important class of organisms, however, was the Polyzoa, of which Fredericella and Plumatella were the chief representatives.

The Polyzoa, or the Bryozoa as they are usually called on the continent, are animals that in some respects resemble the hydra-like polyps. They form colonies that sometimes extend to enormous proportions, hence the appropriateness of their name "Polyzoa," which means "many animals." In the adult stage they lead a sedentary life, firmly attached to some submerged object. The animals

themselves are small, but easily visible to the naked eye. Some of them are covered with a secreted coating, or sheath, that takes the form of narrow, brown-colored tubes; others are imbedded in a mass of jelly. The genera that live in the brown, horny tubes, are the ones that most interest us. They form tree-like growths that often attain considerable length. The branches of the little trees are sometimes an inch long, and each one is the home of an individual polyzoon, or polypide. The branches, or hollow twigs, are separated from the main stalk by partitions, so that, to a certain extent, each polypide lives a separate existence in its own little case, though each was formed from its next lower neighbor by a process of budding. The horny covering is formed of a chemical substance allied to chitin, though in some genera it is calcareous.

The most conspicuous part of the animal is always the circlet of ciliated tentacles. They are mounted on a sort of platform, or disc, called a lophophore, at the forward end of the body. This lophophore, with its crown of tentacles, may be protruded from the end of its protective tube at the will of the animal. The tentacles themselves may be expanded, giving a beautiful, bell-shaped, flower-like appearance. They are hollow, and are covered with fine hair-like processes, or cilia. They are also muscular, and can be bent and straightened at will. By their combined action, powerful currents in the water are set up towards the mouth of the animal, which is situated just beneath the lophophore. Minute organisms are thus swept in as food. In some genera the food material may be watched in its progress through the alimentary canal, but in the animals that dwell in the horny tubes we can only see it disappear into the tube. The animals when disturbed have the power of instantly retracting their tentacles, and this sudden retraction, together with the sly and cautious way in which they afterwards extend them, have long since made the Polyzoa objects of great interest to students of the microscope.

The number and arrangement of the tentacles vary in different genera. In Paludicella, for example, they are 16 in number, arranged in a circle; in Fredericella there are 24, arranged in a sort of oval; while in Plumatella they are much more numerous, and are arranged in a double row in the shape of a crescent or horseshoe.

The body of the organism is a transparent membranous sack, immersed in the jelly or concealed in the brown opaque sheath. It

contains a U-shaped alimentary canal, with a contractile oesophagus, stomach, and intestine; a muscular system that permits some motion within the case, and that causes the extension and contraction of the tentacles; mesentaries in the form of fibrous bands; an ovary, and a rudimentary nervous system. There is no heart nor blood vessels of any kind.

The Polyzoa increase by a process of budding which gives rise to the branched stalks, as we have before remarked. There is also sexual reproduction. In old colonies, especially late in the season, there are often seen small, rounded brown bodies, which, as the animals die, float to the surface of the water. They are the winter eggs, or statoblasts. They are formed within the body, and escape only when the Polyzoon dies, when they emerge, and remain unchanged until the warmth of spring develops them. These statoblasts vary in shape in the different genera and are a valuable aid in identifying species.

The favorite habitat of the Polyzoa is some pond or gently flowing stream where microscopical organisms are plenty. They are often found on the under side of some old board or log. They were once seen covering the entire wood-work of an old dam. They choose shady spots, as a rule, though occasionally they are found in the full glare of sunlight.

They are often found in our water supplies, in the ponds, reservoirs, aqueducts and pipe lines. Boston is by no means the only city where they are met with. They have been observed in many other cities both in New England and elsewhere. Potts speaks of them as being found in the gate houses of the Philadelphia supply, and we have previously referred to their presence abroad. The branching forms seem to be the most important, but the jelly forms are not uncommon. Potts* found the Pectinatella in Fairmount reservoir, Philadelphia, and Crystatella has been often noticed in some of our New England supplies. Perhaps the most notable case of the latter occurred recently in Cape Pond, the water supply of Rockport, Mass. It developed there in great quantities, and was especially abundant on the wood-work at the mouth of the suction pipe. It caused more or less trouble by fouling the sides of the

*E. Potts, "On the Minute Fauna of Fairmont Reservoir," Proc. Acad. Nat. sci., Philadelphia, 1884, pp. 217-219.

stand-pipe, and threatened to become a serious nuisance. The jelly secreting Polyzoa, so far as I am aware, have never been actually observed in the pipes of any water supply.

The fact that the organisms that dwell in water pipes depend for their food material upon the algæ, infusoria, etc., contained in the water, may be easily demonstrated by experiment. Specimens of Fredericella and Plumatella were once placed in a series of jars, some of which were supplied with water rich in its microscopic contents, while others were supplied with the same water after filtration. All the jars were kept in semi-darkness at the same temperature, and were examined daily. The Fredericella and Plumatella that had been supplied with filtered water soon began to die, while those in the other jars lived as long as the experiment was continued. Some of the same Polyzoa were placed in jars furnished with water from the Newton supply, and after about a week they died for want of food. This agrees with what I have learned from the officials of the Newton and Brookline Water Works, that in the distribution pipes of those places such organisms as sponges and Polyzoa are never found. Both supplies are ground water. Dr. G. H. Parker* once made a similar experiment on fresh water sponge, and obtained the same result.

With these facts established, we may confidently affirm that fresh water sponge, Polyzoa, and similar pipe-dwellers will be absent from water pipes where ground water, or water that has been effectively filtered, is used.

One naturally asks, "What is the effect of these organisms growing in the pipes?" In a certain sense they tend to improve the quality of the water by reducing the number of floating microscopical organisms; but they themselves must in time decay, and anyone whose nose has ever had an experience with decomposing sponge will appreciate the fact that better places for these organisms may be found than the distribution systems of our water supplies. It should be stated, however, that in all probability very large quantities would be required in order to produce tastes or odors that would be noticed in the water. No authentic case of trouble from

*G. H. Parker, Experiments on Fresh Water Sponge, Special Report of the Mass. St. Bd. of Health, 1890, p. 618.

this cause has been thus far recorded, so far as I am aware. Perhaps the greatest objection to their presence, is the fact that they tend to impede the flow of water in the pipes. When one considers that a coating ¼ inch thick diminishes the area of the cross-section of a 24-inch pipe by 4 per cent, and of a 6-inch pipe by 15 per cent, and when one learns that these organisms often form layers even thicker than this, it will be seen that such growths are matters of no little importance. Furthermore, fingers of the fresh water sponge sometimes extend several inches into the water, and the matting of the Polyzoa is always rough on account of the stiff branches that are extended into the water in order that the organisms may secure their food. This roughness of the surface must increase the friction of the pipe by an indefinite, but considerable amount.

Summing up the results of these few observations, we learn:

That during the passage of a surface water through the pipes of a distribution system there is ordinarily a considerable reduction in the number of organisms, due to sedimentation, disintegration, decomposition, and consumption by other organisms.

That there is a similar decrease in the number of bacteria, except during those periods of the year when decomposition is going on in the pipes.

That growths of fresh water sponge, Polyzoa, etc., are liable to occur in the distribution pipes of any surface water supply.

That these growths tend to reduce the capacity of the pipes, by diminishing the area of the cross-section and by increasing the friction.

That by their decay, they tend to the production of bad tastes and odors, though it is probable that very large amounts are necessary to give serious trouble.

That these growths of sponge, "pipe-moss," etc., depend upon the minute organisms in the water for their food supply, and that they will die when deprived of them.

And that because of this fact, these growths do not occur in pipes, where the supply is a ground or a filtered water free from microscopic forms.

## TABLE I.

TEMPERATURE OF THE WATER IN THE DISTRIBUTION PIPES, BOSTON, MASS.
(Fahrenheit Degrees.)

| MONTH. | 1891. | | 1892. | | 1893. | | 1894. | | 1895. | | Av. 1891-5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square | Mattapan. | Park Square, | Mattapan. | Park Square. | Mattapan. |
| January | 39.9 | 42.0 | 38.1 | 43.4 | 36.7 | 38.5 | 41.3 | 39.6 | 37.6 | 40.3 | 38.7 | 40.8 |
| February | 40.7 | 39.9 | 38.8 | 40.3 | 36.1 | 35.9 | 37.0 | 38 1 | 36.9 | 38.9 | 37.9 | 38.6 |
| March | 41.8 | 39.9 | 36.8 | 38.9 | 35.8 | 36.0 | 41.9 | 38.9 | 38.0 | 36.6 | 38.9 | 38.1 |
| April | 48.8 | 44.2 | 46.8 | 43 6 | 41.7 | 39.6 | 46.4 | 43.1 | 43.2 | 40.1 | 45.4 | 42.1 |
| May | 56.2 | 50.7 | 55.1 | 49 1 | 53.7 | 47.9 | 59.3 | 51.1 | 57.5 | 49.9 | 56.4 | 49.7 |
| June | 64.4 | 56.9 | 69.0 | 57 2 | 65.7 | 57.2 | 66.3 | 57.7 | 66.7 | 59.1 | 66.4 | 57.6 |
| July | 70.8 | 60.6 | 73.1 | 62.9 | 71 7 | 62.7 | 73.6 | 63.9 | 69.2 | 63.2 | 71.7 | 62.7 |
| August | 72.1 | 62.9 | 72.9 | 64.5 | 71.1 | 64.5 | 72.4 | 66.3 | 70.4 | 63 7 | 71.8 | 64.4 |
| September | 69.0 | 62.5 | 66.7 | 62.3 | 65.5 | 62.4 | 69.3 | 63.0 | 69.3 | 64.3 | 68.0 | 62.9 |
| October | 59.9 | 59.1 | 57.3 | 57.4 | 57 5 | 57.3 | 58.0 | 59.2 | 57.8 | 56.6 | 58.1 | 57.9 |
| November | 47.3 | 51.4 | 47 1 | 50.8 | 47 0 | 50.2 | 46.4 | 50.6 | 48.4 | 51.1 | 47.2 | 50.8 |
| December | 41.7 | 47.0 | 37.9 | 43.7 | 42 1 | 42.8 | 38.7 | 42.8 | 39 6 | 43.9 | 40.0 | 44.0 |
| Mean | 54.4 | 51 4 | 53.3 | 51 2 | 52.0 | 49.6 | 54.2 | 51.2 | 52.9 | 50.6 | 53 4 | 50 8 |

## TABLE II.

NUMBER OF MICROSCOPICAL ORGANISMS (IN STANDARD UNITS* PER C. C.) IN THE WATER IN THE DISTRIBUTION PIPES. BOSTON, MASS.

| Month. | 1891. | | 1892. | | 1893. | | 1894. | | 1895. | | Av. 1891-5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. |
| January | 75 | 28 | 242 | 109 | 66 | 57 | 60 | 25 | 79 | 78 | 104 | 59 |
| February | 29 | 18 | 139 | 112 | 14 | 9 | 50 | 27 | 14 | 6 | 49 | 34 |
| March | 34 | 13 | 101 | 57 | 5 | 7 | 38 | 13 | 12 | 5 | 38 | 19 |
| April | 188 | 65 | 190 | 191 | 46 | 46 | 152 | 92 | 38 | 26 | 123 | 84 |
| May | 313 | 167 | 267 | 97 | 212 | 103 | 126 | 76 | 93 | 42 | 202 | 97 |
| June | 206 | 80 | 350 | 76 | 308 | 66 | 137 | 72 | 233 | 111 | 247 | 81 |
| July | 356 | 106 | 478 | 212 | 336 | 96 | 125 | 48 | 373 | 155 | 334 | 123 |
| August | 201 | 81 | 212 | 81 | 199 | 49 | 71 | 29 | 188 | 47 | 174 | 57 |
| September | 452 | 124 | 214 | 75 | 347 | 205 | 155 | 85 | 142 | 19 | 262 | 102 |
| October | 374 | 152 | 220 | 78 | 679 | 330 | 173 | 83 | 258 | 63 | 341 | 141 |
| November | 421 | 88 | 111 | 64 | 311 | 84 | 84 | 71 | 138 | 42 | 213 | 70 |
| December | 295 | 68 | 95 | 69 | 155 | 48 | 196 | 269 | 140 | 50 | 176 | 101 |
| Mean | 245 | 83 | 218 | 102 | 223 | 92 | 114 | 74 | 142 | 54 | 189 | 81 |

*One Standard Unit equals 400 square microns.

## TABLE III.

AMOUNT OF AMORPHOUS MATTER (IN STANDARD UNITS* PER C. C.) IN THE WATER OF THE DISTRIBUTION PIPES, BOSTON, MASS.

| MONTH. | 1891. | | 1892. | | 1893. | | 1894. | | 1895. | | Av. 1891-5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. |
| January | 32 | 10 | 160 | 226 | 98 | 122 | 182 | 117 | 94 | 80 | 113 | 111 |
| February | 26 | 16 | 66 | 125 | 84 | 44 | 157 | 128 | 92 | 74 | 85 | 77 |
| March | 30 | 27 | 94 | 149 | 88 | 46 | 166 | 70 | 100 | 61 | 96 | 71 |
| April | 134 | 47 | 136 | 140 | 116 | 72 | 169 | 103 | 132 | 82 | 137 | 89 |
| May | 216 | 40 | 241 | 170 | 396 | 88 | 170 | 75 | 363 | 113 | 277 | 97 |
| June | 271 | 73 | 188 | 250 | 324 | 90 | 197 | 154 | 216 | 98 | 239 | 133 |
| July | 289 | 205 | 214 | 162 | 372 | 125 | 224 | 101 | 332 | 154 | 286 | 149 |
| August | 172 | 89 | 87 | 52 | 318 | 123 | 253 | 152 | 248 | 98 | 216 | 103 |
| September | 102 | 85 | 203 | 76 | 299 | 157 | 273 | 130 | 194 | 95 | 214 | 109 |
| October | 211 | 55 | 181 | 63 | 441 | 187 | 235 | 118 | 236 | 103 | 261 | 105 |
| November | 160 | 51 | 141 | 90 | 447 | 225 | 153 | 113 | 143 | 88 | 209 | 113 |
| December | 180 | 96 | 83 | 79 | 185 | 101 | 164 | 194 | 102 | 67 | 143 | 107 |
| Mean | 152 | 66 | 149 | 132 | 264 | 115 | 195 | 121 | 188 | 93 | 190 | 105 |

* One standard unit equals 400 square microns.

## TABLE IV.

NUMBER OF BACTERIA PER C. C. IN THE WATER OF THE DISTRIBUTION PIPES, BOSTON, MASS.

| Month. | 1892. | | 1893. | | 1894. | | 1895. | | Av. 1892-5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. | Park Square. | Mattapan. |
| January | 113 | 92 | 257 | 58 | 73 | 54 | 95 | 69 | 135 | 68 |
| February | 86 | 75 | 690 | 178 | 42 | 84 | 25 | 23 | 211 | 90 |
| March | 120 | 55 | 110 | 52 | 32 | 30 | 146 | 64 | 102 | 50 |
| April | 65 | 65 | 54 | 73 | 32 | 72 | 55 | 37 | 52 | 62 |
| May | 67 | 70 | 63 | 155 | 30 | 107 | 50 | 85 | 53 | 104 |
| June | 61 | 133 | 64 | 171 | 157 | 92 | 62 | 106 | 86 | 126 |
| July | 61 | 161 | 97 | 229 | 46 | 80 | 89 | 156 | 73 | 157 |
| August | 61 | 91 | 103 | 76 | 102 | 65 | 56 | 34 | 81 | 67 |
| September | 102 | 58 | 75 | 51 | 109 | 60 | 58 | 37 | 86 | 52 |
| October | 71 | 46 | 68 | 84 | 29 | 42 | 50 | 17 | 55 | 47 |
| November | 63 | 36 | 59 | 53 | 50 | 30 | 50 | 19 | 56 | 35 |
| December | 39 | 29 | 79 | 84 | 27 | 22 | 65 | 23 | 52 | 40 |
| Mean | 76 | 76 | 143 | 105 | 61 | 62 | 67 | 56 | 87 | 75 |

TABLE V.

NUMBER OF MICROSCOPICAL ORGANISMS, BACTERIA AND AMORPHOUS MATTER IN MYSTIC RESERVOIR AND A TAP IN CHELSEA, MASS. 1890–1893.

| Month. | Microscopical Organisms. (Number per c. c.) | | Bacteria. (Number per c. c.) | | Amorphous Matter. (Number of Units per c. c.) | |
|---|---|---|---|---|---|---|
| | Mystic Reservoir. | Tap in Chelsea. | Mystic Reservoir. | Tap in Chelsea. | Mystic Reservoir. | Tap in Chelsea. |
| January | 233 | 190 | 1,712 | 1,375 | 423 | 145 |
| February | 79 | 46 | 5,500 | 6,651 | 426 | 78 |
| March | 1,367 | 913 | 539 | 399 | 183 | 41 |
| April | 12,796 | 5,385 | 566 | 214 | 221 | 61 |
| May | 7,667 | 6,845 | 107 | 152 | 296 | 196 |
| June | 1,684 | 967 | 137 | 94 | 401 | 419 |
| July | 659 | 367 | 122 | 400 | 426 | 266 |
| August | 1,164 | 715 | 975 | 840 | 175 | 140 |
| September | 1,251 | 483 | 370 | 341 | 203 | 216 |
| October | 543 | 155 | 301 | 218 | 278 | 71 |
| November | 392 | 272 | 118 | 412 | 357 | 84 |
| December | 481 | 235 | 1,829 | 894 | 408 | 105 |
| Mean | 2,360 | 1,381 | 1,023 | 999 | 317 | 152 |

DISCUSSION.

PROF. PORTER: I would like to ask if anything is known as to the effect of the speed of the current on the formation of these growths on the inside of pipe?

MR. WHIPPLE. We know only that where the current is very rapid we do not find them. Where there is no current at all we do not always find them, because food is not being carried to them. The most favorable condition is a gently flowing current, but we cannot give any figures such as the number of feet per second.

MR. FULLER. I would like to ask Mr. Whipple how much flushing is required to remove these growths, whether it is possible by ordinary flushing to remove them?

MR. WHIPPLE. I do not believe that the ordinary flushing would remove them. You have got to increase the current to such an extent that they are really broken from the sides of the pipe. They are very firmly attached, and they are extremely tough.

MR. CHACE. I think the Association is greatly indebted to Mr. Whipple, and to the Boston Water Works, not only for this paper,

but, in general, for their biological studies. I myself feel personally indebted for information I have obtained from the reports of the Boston Water Works. For example, I remember reading in a report a year or two ago that in the Boston water they found the organism Dynobrion very common in spring months, at the time the ice was breaking up, and that the prevalence of this organism produced a bad taste in the water. I immediately looked at the analysis of the waters of our Lakeville ponds to see if we had any there, and I found that it was quite numerous in the Assawompsett water, but not in the Elder's water, so I immediately discontinued drawing from one pond to the other in the month of March. That is one case in which I have received benefit from the work of Mr. Whipple and his associates, and I do not doubt others of you could tell similar experiences.

A MEMBER. I would like to ask Mr. Whipple if there is any coating which can be used to prevent those growths?

MR. WHIPPLE. That is something I cannot answer, but I propose some time to make experiments along that very line. We know a rough surface favors the growths of organisms, for it furnishes a good place for them to become attached; further than that I cannot say.

THE PRESIDENT. I would like to ask Mr. Whipple, if in his examinations he has had opportunity to see whether the difference is perceptible between the number of organisms present in surface water and ground water.

MR. WHIPPLE. I know, as I said, that in the town of Brookline and in the city of Newton, there are practically no organisms growing in the pipes; that is, I learn so from the superintendents. I have examined the pipes of half a dozen or more surface water supplies in various cities, and I have almost always found them; in fact, I think I have never failed to find them.

THE PRESIDENT. I don't know but the Newton and Brookline superintendents may have had examinations made as to whether there were really any organisms in the water pipes, but are you fully posted as to that?

MR. WHIPPLE. I once asked the superintendent of the Brookline Works particularly regarding that fact, and that is what he told me; and perhaps Mr. Whitney, if he is here, can answer for the Newton water.

THE PRESIDENT. There is no one better aware than Mr. Whipple that to an ordinary observer, the water pipe might look entirely free from any organism whatever, while a biological examination would reveal the fact it was teeming with these organisms. Now, as long as we do not know that there was any microscopical examination of that ground water, I should feel assured that it was full of organisms, certainly to quite an extent.

MR. WHIPPLE. The organisms of which I have been speaking are not microscopical. They are quite easily seen by the naked eye. The large growths are fully a quarter of an inch long, and I don't think anybody would be likely to overlook them; that is, if he were looking for them.

# WOONSOCKET WATER WORKS RESERVOIR AND DAM NO. 3.

BY BYRON I. COOK, SUPERINTENDENT, WOONSOCKET, R. I.

[*Read Sept.* 9, 1897.]

Reservoir No. 3, of the Woonsocket Water Works, is situated in the towns of North Smithfield and Smithfield, five miles from the city of Woonsocket, and two and one-half miles from the pumping station on the Crook Fall brook, the same that supplies Reservoirs Nos. 1 and 2. The pumping station is located at Reservoir No. 1, No. 2 being about 1,000 feet up stream from No. 1. The storage capacity of Reservoirs Nos. 1 and 2 is 52,000,000 gallons, with a water-shed of 7.9 square miles. This was insufficient in a dry season, with an average daily consumption of 1,000,000 gallons, and the year previous to the completion of Reservoir No. 3 the city came very near suffering a water famine. Although warned by the Water Board of the necessity of additional storage, it was not until unwatered streets became unbearable from dust, drinking fountains dry, lawn hose useless, and the public out of sorts, that an appropriation was made for the necessary surveys, and purchase of land. (I will say right here, if any Superintendent is ever so unfortunate as to be obliged to ask the water consumers to economize in the use of water on account of short supply or accident, that I hardly think that his request will be complied with to any extent; the only curtailment will be the consumption directly under his supervision, such as drinking fountains, etc. Unless the water consumers of other cities and towns are different than those of Woonsocket, the only one to turn to for aid will be the weather man, and I hope he will help you out as he did in our case.)

Surveys for the proposed reservoir and dam were commenced early in 1894, and during the spring negotiations were commenced for the necessary real estate. Of course land values had advanced in the vicinity of the proposed site. Abandoned farming land was valued as much as corner lots in a flourishing town. It became necessary

to ask the Legislature for an "Act of Condemnation." This was granted at its May session, 1894. All parties interested were settled with, out of court, except two.

The law of Rhode Island grants the right to parties owning land taken under an act of condemnation to have their damages assessed by a jury, and it is surprising the difference of opinion of the men that comprise the jury, of the value of real estate. In one suit for a tract of 50 acres, I was told by one of the jurymen after the trial, that upon retiring to the jury room after the testimony had been submitted, and before the case had been discussed, each man gave his opinion as to the amount of the award. The highest was $8,000, lowest, $900; verdict, $2,800.

The reservoir flows an area of 197 acres. Its greatest depth is 16 feet; average depth, 9 feet; storage capacity, 529,000,000 gallons. Its elevation is 323 feet above tide water, and 167 feet above Reservoir No. 1. It has a water-shed of 1,944 acres of abandoned farming and wood land. Only two farms are under cultivation. The total population of the water-shed in 1895 was 14. Sufficient land was purchased to control the shores of the reservoir, the adjoining ownership at the nearest point being 100 feet from the flowage line, and on the north side, where the shed is the steepest, the land was purchased 1,000 to 1,500 feet from the flowage line.

The reservoir site was cleared of all brush and trees and thoroughly burned over. An estimate was made of the probable cost of removing the soil, and the expense was more than the city could afford. Another consideration entered into the outlay. The water is carried from Reservoir No. 3 to No. 2 in the open brook between the two. The brook has two large tributaries. These drain large swamp areas. It would have been necessary to have drained these swamps if the full value was to have been received from the expense of the removal of the soil in the reservoir. With the progress that has been made in the past few years with filtration of drinking waters, it was considered advisable to investigate the subject before making any large outlay in draining the swamp land.

The dam is located at the easterly side of the reservoir, and was built by contract. It is at present 1,300 feet long, 36 feet wide at top, and 28 feet high at its greatest height. The dam is so designed that when additional storage is required it can be raised 6 feet, increasing the area flowed to 240 acres, with a holding capacity of

875,000,000 gallons, the estimated yield of the water-shed. The dam is built of earth, with a core wall of concrete and 2-inch spruce sheeting. A spillway or overflow, 25 feet in width and 5 feet high, is located in the dam near the southerly end, and is built of granite. The up stream embankment is sloped 2 to 1, and rip-rapped with cobbles not less than 6 inches in diameter. The down stream embankment is sloped 1½ to 1, and is dressed with loam. Two effluent pipes, 20 inches in diameter, placed 3 feet on centers, pass through the dam near the spillway and are encased in concrete. These pipes are 16 feet below the flowage line, and draw the water only at that height. Four 20-inch Chapman valves are placed on the effluent pipes at the down stream end, and are placed 30 inches apart. These valves are flanged and bolted to the effluent pipes. The upper two are always open, the lower set controlling the flow of water. This set, in case of repairs, can be unbolted and passed out under the gate house through an archway, this archway at present being filled with a 12-inch wall.

The material underlying the core wall is of hard pan. Soundings 15 feet below the bottom of the core wall did not reach the ledge. The average depth of the core wall below the original surface of the ground is 15 feet. If it had required it, a single row of hard pine sheeting, 6x12 inches, would have been driven under the center of the core wall.

The core wall is 7 feet wide at the bottom and 3 feet wide at the top. It is composed of one part Rosendale cement, two parts coarse sharp sand, and four parts broken stone, screened to pass a 2½ inch mesh. It was laid in layers of 8 inches and rammed. It extends from the south end of the dam 550 feet, where it is joined to the 2-inch spruce sheeting. The up stream side is plastered with cement.

The 2-inch spruce sheeting, tongued and grooved, 20 feet long, extends from the core wall the remaining portion of the dam. It is footed into 12 inches of concrete. The excavation for the sheeting was refilled with selected material and puddled.

The embankments are composed of blue marl and gravel. The material for the up stream embankment being selected, all material was laid in layers of 4 inches and immersed with water. The constant passing and re-passing of the carts was sufficient to compact the material without the use of a roller.

The spillway was of granite and classed as broken ashler. The steps were of granite, fine pointed on face and top. The coping was fine pointed on face, and peen hammered on top. The steps and coping were laid in Portland cement.

The spillway between the core wall and the up stream shoulder of the embankment was paved with selected stone, not less than 1 foot in thickness.

The spillway apron was laid with large flat stones, weighing not less than 2,000 pounds, laid on concrete and thoroughly grouted, extending 80 feet from spillway steps. In front of effluent pipes an apron of hard pine 6x8 inches, 20 feet long, joined the spillway apron. This apron was laid on concrete.

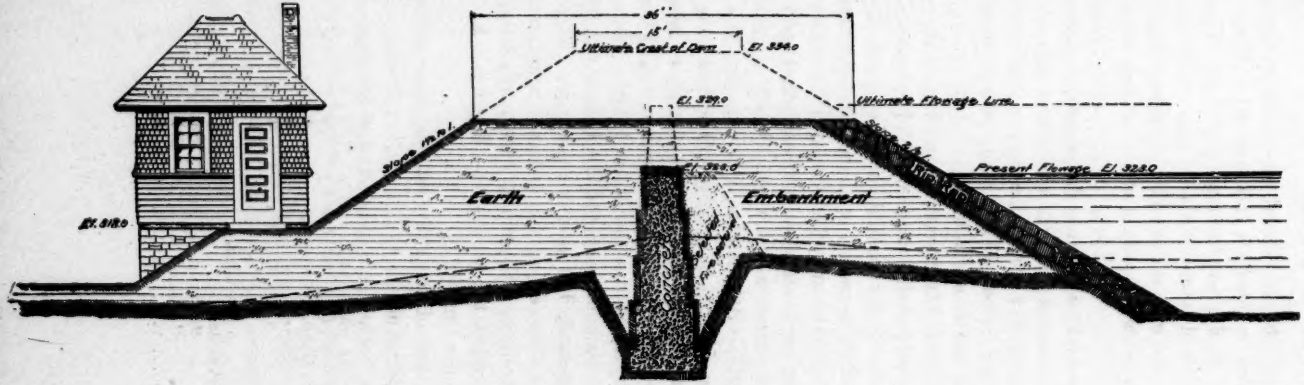
The gate house is of wood, 12x15 feet. A portion of the outside walls are shingled, the inside being finished with hard pine sheathing. All exposed parts of the foundation are of broken ashler. The gate house contains the necessary appliances for the operation of the gates, which were furnished by the Chapman Valve Company.

The Rosendale cement used was the Hoffman brand, and it required 4,474 barrels to complete the work. 1,348 samples were tested for tensile strength. 704 samples, 1 hour in air, 23 hours in water; minimum allowed, 50 pounds; average, 93 pounds; maximum, 177.5 pounds. 644 samples, 1 day in air, 6 days in water; minimum allowed, 70 pounds; average, 114.5 pounds; maximum, 197 pounds.

The Portland cement used was the Alsen brand. Number of barrels used, 40. Four samples were tested 1 hour in air, 23 hours in water; minimum allowed, 140 pounds; average, 210 pounds; maximum, 250 pounds. One day in air, 6 days in water; minimum allowed, 235 pounds; average, 305 pounds; maximum, 350 pounds. The cement was delivered at the dam site,—Rosendale $1.25 per barrel, Portland $3.20 per barrel.

The following is the cost of the different quantities taken from force account, and material used:

| | | |
|---|---|---|
| Grubbing and clearing dam site | $ 0.35 | per cubic yard. |
| Wet excavation, including pumping | .82 | " " " |
| Puddled earth embankment, (avg. haul 800 ft.) | .35 | " " " |
| Rip-rapping up stream slope | .36 | " " " |
| Loaming down stream slope | .31 | " " " |
| Spillway paving | .36 | " " " |
| Concrete, including cement | 3.41 | " " " |
| **MASONRY.** | | |
| Broken Ashler, without cement | $ 25.59 | per cubic yard. |
| Rubble, " " | 4.64 | " " " |
| Apron paving, " " | 3.60 | " " " |
| Gate house | 582.36 | |

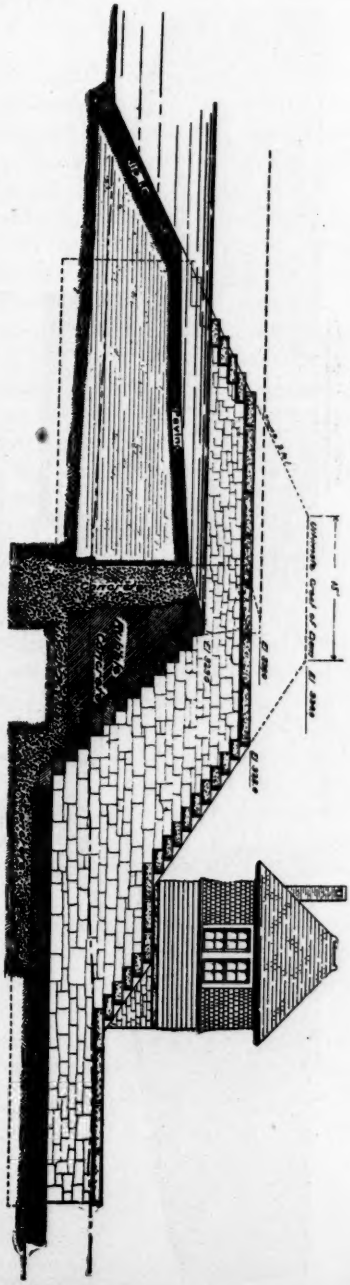



**CROSS SECTION OF DAM.**

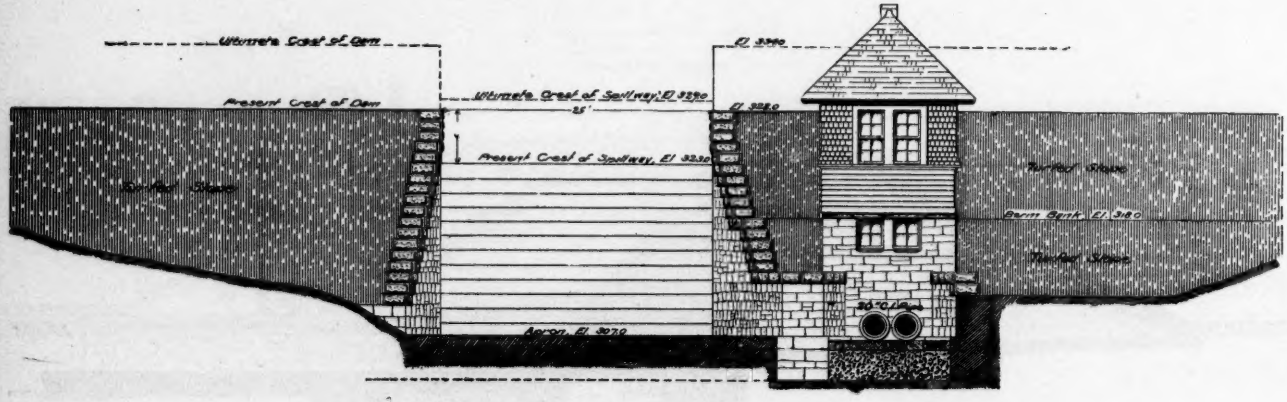
-FACING SOUTH-

SCALE

F.A. Caldwell, Del.



CROSS SECTION OF SPILLWAY.




ELEVATION

SPILLWAY & GATE HOUSE.

SCALE

DISCUSSION.

MR. STACEY. I would like to ask if the water has been used by the city continuously since the reservoir was filled, in connection with the other water, and if so what has been the result of flowing the reservoir without the removal of any of the soil, and only removing the shrubbery and burning it over?

MR. COOK. I will say, in reply to Mr. Stacey, that last season it was necessary to draw upon the reservoir. The water starts from the reservoir and runs two and a half miles in the brook, dropping about 167 feet. There has been no complaint, and it has been impossible to detect any trouble with the water at the pumping station. There is no question but it would have been better to have stripped the reservoir of the soil, but the expense was more than the city could stand; and, as I state in my paper, with the subject of filtration in the state in which it is at present, it was decided to wait and, if possible, to filter the water, in preference to draining the swamps and taking the soil from the reservoir.

THE PRESIDENT. I would like to ask Mr. Cook if it would have added very much to the expense of this reservoir to have put the spill-way at either side, rather than in the portion of the main dam, where it is?

MR. COOK. Yes sir, I think it would. And the character of the land each side was not so good for locating the spill-way. I can see Mr. Haskell's point. There is some question about locating a spill-way out in the dam, but where, as in this case, it is thoroughly incorporated in with the core wall.—You will observe on this section that the concrete wall and the backing for the spill-way steps are thoroughly bonded together.—I cannot see how there would be any trouble from leakage at that point. We have never discovered, since the reservoir was built, any leakage at all through the steps, or on them.

THE PRESIDENT. I would also like to ask Mr. Cook if he observed during the summer any particular growths of organisms in the water, or has the State Board of Health made monthly analyses of the water and discovered anything?

MR. COOK. Down here in Rhode Island we are not so particular about such things, or not so well fortified against them, as you are in Massachusetts. Our State Board of Health, so far as regards

water supplies, does very little. But I can say that I did discover in the reservoir, during the first season, a growth. We could not detect anything of the kind at the pumping station, however, and I account for that, as I have said before, by the fact of the water running so far and dropping, as it does, 167 feet, which gives it a chance to aerate itself. At one place within a thousand feet, the brook drops about 60 feet.

MR. STACEY. If I understood Mr. Cook correctly, he stated that there were tributaries to the brook, draining a large area of swamp on two sides.

MR. COOK. Yes, sir.

MR. STACEY. And that has always been so; that is, they were tributary to the original supply.

MR. COOK. Yes.

MR. STACEY. And you never had any trouble from the water from this locality?

MR. COOK. None whatever.

MR. STACEY. The reason I am interested in this, is that we are in almost the same condition, although we stripped to a certain extent the shallow flowage of our reservoir, and we have 10 feet or more of water on everything that is not stripped. The city of Boston has been building reservoirs lately all around us, and the reservoirs have been put into use as soon as constructed, for the demand for water has kept up with the supply, and there has been a great deal of criticism on the part of some people, because in constructing our reservoir we did not thoroughly clean the bottom. But we have had the same idea Mr. Cook has, in regard to filtration. We looked at it in this way: That it was going to cost us a large amount of money to clean the basin of the reservoir, and we had to spend some money cleaning the shores, and while we might have a clean reservoir, one free from vegetable matter, which would be a very desirable thing, still we would have no defense against the water-shed, which was liable to contamination. By the time we were obliged to draw from that reservoir six or eight months in a year,—we are only obliged now to draw two or three, or possibly four months,—the development in filtration, both mechanical and the European system of sand filtration by irrigation, would have reached such a point it would warrant us in waiting. And it was a question in my mind, whether it was not a better plan to wait until we could adopt some

system of filtering the water as it goes to the consumer, rather than to spend about the same amount of money in cleaning up the comparatively small area of the basin which contains the water, which flows from an unprotected water-shed. We have used that water for three or four years, using it at the time of year when the water is at its best, in the winter and early spring months, and while our original supply was considered excellent, and is so shown by the analyses of the State Board of Health, we have failed to see where there was any difference between the water from the new reservoir and that from the old, at the season of the year when that water is used. Of course there is a great difference between the water at the surface and at the bottom. We took it three or four feet from the top, and we couldn't see any difference either in the color or in the organisms contained in the water.

THE PRESIDENT. I would like to ask Mr. Cook if the character of the bed of this reservoir was sandy, or whether there were muddy areas which had quite a considerable amount of soil and muck?

MR. COOK. The greater portion of the reservoir flowed was of a swampy character. It would have been necessary to have gone to a considerable depth in stripping the soil off the reservoir to have taken all the vegetable matter. The muck in some places was 3 to 4 feet deep, for 50 to 75 feet each side of the channel of the brook where it passed through the swamp.

THE PRESIDENT. I would like to say a few words myself in connection with this matter of cleaning reservoirs. Where a city is putting in a large reservoir, it is a question of great importance. One thing is settled, that we must have purer water than we have been furnishing in the past. The best way to get it is a question which is to-day receiving a large amount of careful study, and there is quite a good deal of difference of opinion among Water Works men as to how to arrive at that result. Boston has perhaps made the greatest effort to purify the basins, where they were starting in for a new water supply, that has been made in the country, and the result has not yet demonstrated that the expenditure of money in that direction can be considered to be the best expenditure which is possible. It is a well known fact, as appears from the reports that the State Board of Health have given of the quality of the water in these cleared reservoirs, that it does not come up to the standard we ought to apply when we talk about giving pure water. There

are times in the year when there are organisms existing in these reservoirs to a greater amount than is desirable, and certainly to such an extent that I should expect to hear from some of our water takers, if we were supplying them with the water.

Now, there is this which can be said in favor of cleaning a reservoir. We all will readily admit that soil and muck, and every substance of that character in a reservoir, favors the growth of organisms, and forms an element from which a great deal of trouble is to be apprehended. But we also know that in former years there was no attempt made to purify water in this way, and we do know that from year to year the basins have improved, so that, varying according to the character of the reservoir, usually within a period of ten years, ponds have been brought to a condition by natural causes that has pretty fairly paralleled what we find in these new cleared reservoirs.

Furthermore, let us consider what is the practical condition of a pond, we will say in ten years after it has been cleared and filled? All these reservoirs have a large amount of water flowing into them in streams, which carry a good deal of soil and other things, depending very much on the character of the water-sheds through which the streams pass. Now allowing that we start with a perfectly clean pond, as is supposed now to be the very best. From year to year all of this floating debris and soil and everything that comes down, is going to be deposited upon the bed of that pond, and it seems to me that experience is going to show us that the natural causes have intervened to render the bed of a pond that has been cleaned almost in the condition in which it formerly was. Now, we haven't had an opportunity to thoroughly demonstrate that, but indications, as I look at them, point to our arriving at that result. Well, if that result is to be reached, it does seem as though this great expenditure of money that we are forced to go to to clean out the bed of a reservoir, is perhaps unwise. As Mr. Cook says, we undoubtedly are going to have filtration as the practical method of purification of surface water supplies, and it looks to me that, granting the water may be somewhat worse in a basin that has not been cleaned, the final result after filtration and purification is going to be practically the same. And it does seem, as both Mr. Cook and Mr. Stacey have said, that it is a question which requires quite a little deliberation before we spend too much money in cleaning out reservoirs.

MR. COOK. Mr. Haskell's remarks have been just in the line of the arguments which were used in our case. As I have said, the trouble with the Woonsocket water is the color. If we had gone to the expense of cleaning our reservoir, 197 acres, at an expenditure of not less than $100,000, we should not have been any better off, so far as color is concerned, than we are with the reservoir in its present state. Passing as it does down through quite a large area of swamp, our water would have been just as high colored when we received it at our pumping station as when it left the reservoir, and we considered that in view of the progress which is being made in filtration, it would be better to put our money into a filter plant, either mechanical or sand, rather than into cleaning the reservoir.

MR. FULLER. I would like to ask Mr. Cook if he made any estimate of the expense of filtering the supply?

MR. COOK. We did not to any great extent. It is my opinion that a mechanical filter, sufficiently large for our use at the present time, can be put in for about $50,000. The cost of sand filtration we didn't go into. I believe the time is coming when most of the water supplies in New England have got to be filtered, for the people are going to demand it.

MR. CHACE. I suppose the members are aware that ordinary filtration does not remove color. In order to remove the brown color from swamp water, the process of filtration would have to be supplemented by the use of some kind of a precipitant like alum, and the State Board of Health have condemned that, as an excessive amount of alum is likely to be injurious.

THE PRESIDENT. I think when we come to the question of color in water we are opening up quite a question. The qualities that give color to water are very distinct, and sometimes color in water does not mean it is bad water at all. There may be a certain amount of carbon in the earth that would color a water very highly, but would not injure the quality of it at all. The principal cause of color in this reservoir is probably the swamps in the water-shed. It might be possible that a very small swamp might have added very much to the color. I have seen water taken from a brook just below a cedar swamp where the color ran up as high as 700. Well, you can readily see how that is going to affect the color in the pond, where the color ought to be probably about .040. Now, if in this water-shed there was an area of 30 acres, and a cedar swamp the

water from which was colored up to 700 at certain times of the year, the remaining portion of that entire area might be down to a very fine color, and still the water in the reservoir be highly colored. Our State Board of Health in Massachusetts think that there should not be any color in the water. Of course that is very desirable, but it is going to be very difficult to get all the color out, and when you get down to .070 it is not perceptible at all in a tumbler. I myself feel that it is sufficiently fine to draw the color line to a point where, when a person picks up a tumbler of water, the water looks colorless. Well, at .070 there are very few who would notice the color, particularly if they were quite thirsty.

I think that there would be no difficulty in bringing the water in the Woonsocket reservoir down certainly to an average of .070, for I have done some careful work in areas that are something like that there, and I have found no difficulty, where we had a color of 300, in reducing it down to .040 by a system of drains running around the portions of the water-shed that the color came from, eliminating all that portion of the water-shed which was above those low figures and stopping the water from running down into the swamp and getting the color. I don't imagine that it would be an item of very large expense to remove the color of the Woonsocket water down to .070. That is something which is going to attract a little attention in the future, the care we take of our water-sheds, for, although filtration may take everything out, it is very desirable not to get anything in. We want to start with the water just as pure as we can get it, and we want to do it in the cheapest way. The different methods have got to be carefully studied, and we are going to know more on this subject than we do now. One way to learn is to talk these things over, and get at the different ideas of the members about them.

MR. HAZEN. The question of color, of course, is an important question;—important, as our President has said, because of the color itself, and not because of any unhealthful property in the color. The coloring matter is something, perhaps, like that which gives color to coffee, and we certainly don't care to have our coffee as light colored as even the darkest of the waters. But it is pleasanter to have a colorless water on the table than a yellow water. It is a matter of taste. We like to have some of our drinks colored, but we like to have our water white.

The question of the removal of color by filtration is a difficult one. Passing water through sand in the ordinary course of filtration always removes some of the color. If the filtration is rapid and the sand layer is not very thick, the proportion of color removed is very small—hardly noticeable. In filtration through a thicker layer of sand and at a lower rate—as, for instance, in the Lawrence filter,—from one-half to one-third of the color of peaty waters is removed, seldom more. The proportion of color removed depends upon the character of the sand. A pure quartz, like the Berkshire sand, removes hardly any color, while some sands, containing a good deal of iron, aluminum or manganese, remove a very large proportion of the color. They may remove all of it for a short time and a large proportion of it for a long time. I had the pleasure last fall of visiting some filters in England for the supply of the city of Liverpool, where the sand had been in use for some thirty years. They were filtering a quite yellow water, and the proportion of color removed at the end of thirty years, without changing the sand, was from two-thirds to three-quarters of the total color of the water, so that the effluent from a very highly colored supply was practically colorless. This sand was very dark colored, almost black, and had an extraordinary property of getting rid of the color. The city of Liverpool has recently constructed some other filters, in which another kind of sand was used which it was thought would be better than that old sand, but it was found that it removed not more than a third of the color.

The color of peaty water can be removed by the use of alum. It takes more alum to remove the color than has been commonly supposed. I have been furnished with records of the amounts of alum actually used in removing colors from peaty waters during the last year, by members of this Association and by others, and I have been surprised at the large amount of alum which it is necessary practically to use to get rid of the color. In the waters of the middle states there is usually a considerable amount of lime carried in solution, which makes the waters hard, and this lime will decompose a large quantity of alum completely, so that almost any quantity that is required in water purification can be added to the water, and the decomposition will be complete, and the alum will be removed, and the sulphuric acid will be in the effluent as sulphate of lime. In many eastern waters, in New England waters particularly, there is

very little lime in solution, and with these waters it is not possible to add large quantities of alum without using up all the lime and leaving an excess of acid and a quantity of undecomposed alum which is objectionable. I have known cases of this kind where quite serious trouble has been caused by rendering the water acid.

A number of other means of removing color have been suggested as a substitute for alum. One of the earliest and most important of these was the Anderson process, in which the water was brought in contact with metallic iron, the idea being to oxidize the iron, forming ferric hydrate, which would do the same work in the water that the alum would do, but without the addition of the sulphuric acid to the water. This process has been in some cases apparently quite successful, but with New England waters it has been found that the iron will not be acted upon fast enough to make it a practical success. It is necessary to keep the water in contact with the iron in motion for so long a time as to make the cost practically out of the question. Recently there have been several schemes suggested for hastening this action by means of electric currents, and aluminum has been suggested to take the place of iron. These processes have been tried in an experimental way in a few cases, but I do not know that any practical results have been obtained from them as yet.

I can simply say that by the use of sand, particularly when a sand can be secure which has a peculiar power for removing color, it is possible to remove a great deal of the color, and in many cases enough can be removed so it will not be objectionable. When the water is very highly colored or filtering material of the peculiar quality is not obtainable, the only way in which to get rid of the color is to use some coagulant or its equivalent, and the best way of getting at that is one of the questions which is still under active discussion and investigation.

MR. FULLER. I would like to ask Mr. Hazen if the matter that causes the peaty taste in water is the same which causes the color?

MR. HAZEN. So far as I know it is, Mr. Fuller. We certainly find the two things associated with each other and going together.

THE PRESIDENT. I should like to ask Mr. Hazen if he has any information to furnish in relation to the relative expense of filtering a city's water supply by mechanical and sand filtration?

MR. HAZEN. The cost of mechanical, and also of sand filtration, depends altogether upon local conditions. In certain cases beds of

sand are found, which are exactly suited for sand filtration, right on the ground. If the places are far enough south so that open filters can be used, sand filters can be constructed very cheaply. In other cases there may not be a sand bank in a hundred miles, and covered filters may be necessary, and the cost will run up to several times the cost of mechanical filtration. The cost of mechanical filtration will also vary very much with what you require. The mechanical filters were formerly operated at the rate of 3 gallons per square foot of area per minute. Now they are running filters at a half or a third of that rate which means a very much larger area. Then it depends upon what is required in the way of a mechanical filter. Some mechanical filters are simply washed by a reverse current; others have stirring devices and other arrangements. If you are satisfied with the simplest apparatus, you can build a mechanical filter very cheaply indeed. But, on the other hand, if the best devices for stirring the sand and regulating the rate of flow, and so forth, are required, the cost of mechanical filters runs up considerably A three million gallon sand filtration plant, which I was interested in last year, and which was built by day labor for about 10 per cent. less than the lowest bid for a mechanical plant of the same capacity. The conditions there were very favorable. Under other conditions the comparison would not be at all the same.

## SERVICE BOXES.

BY GEORGE A. STACEY, SUPERINTENDENT, MARLBORO. MASS.

[*Read Sept.* 9, 1897.]

The question of service boxes was brought up at one of our previous meetings, and it was suggested at that time, there being no discussion of the subject then owing to the lateness of the hour, that perhaps there might be some information of a practical nature which, if there was time at this meeting, might be brought out here by bringing up the subject again. It seems almost trivial to speak of a thing like that, but at the same time it is one of the many little things which goes to make up the great whole, and in regard to this, as to many other things, we are not all situated under the same conditions, and do not all think alike. This subject was brought to my mind in the first place by the occurrence several times of trouble in the winter on a cold night,—all our troubles come in a cold night, you know. Of course you go to the place and suppose everything is all right, so you can turn off the water and can get back to bed again, but you find some boy has smashed the box some time during the summer, or a stone has worked in somewhere, and the water can't be shut off. Now the trouble with gate boxes with me is from the displacement or the heaving of the box by frost, the ground being largely composed of hard-pan and clay, which expands to a very large extent in the winter and lifts the box. The gate box we have used has been in two sections, like the majority of the gate boxes, and the last kind which was used was the old Buffalo screw box. When they first came out the thread on the screw was fitted comparatively close. Shortly after that it was made larger in the thread on the upper section, and as small as possible on the lower section, so as to give the box as much leeway to come and go as possible. Well, if they had about six times as much as they have now it wouldn't be any too much. The trouble is the box comes up, and we have to drive it down again,—we have to drive the whole box down. If the bottom comes up, when you drive it

down you will find that the tendency of the material is to work under the box, and if there is a stone anywhere in the vicinity I believe it comes to that place to get up in there. And while you can take some water and get out the soft material by churning it up and down, the stone will not go out, but will stay in there and get in its work. Then we find in boxes where the wrenches go clear down to the stop and waste, that the tops are broken, that they are not heavy enough to stand the work of the small boy, or a coal wagon, or the other things we have to contend with, and the whole thing is disarranged in time by frost, and the boys, and the general hard usage which such a thing gets.

Now in concrete sidewalks, and in places where there is perfect drainage of the land, these troubles would not exist, and in some places in our city where we have concrete walks, and we have a large number of them, we don't have any trouble in this way. But in other sections of the city we will find a box standing up from the concrete walk in the spring of the year sometimes three inches. Of course in the main streets this does not occur, for the boxes are forced down by the travel over them.

My idea of a gate box is that it should be made of two parts, a telescope pattern, the top and bottom entirely separated, as far as any mechanical connection is concerned. The bottom should be of sufficient size to withstand an upward thrust, and fit close enough around the stop and waste and pipe to exclude the possibility of any material getting around it. The top should be perfectly free, with a very generous flange, and with a cover sunk into it so it will stand any ordinary hard usage. When you can get a box of that kind and set it, you will be pretty sure to find it in the same condition in which you set it two or three years afterwards. The rod should extend enough so you can get a wrench onto it, and it must be heavy enough so that corrosion will not weaken it, so that it will not twist off and leave you in worse shape. You must have it sufficiently heavy to compensate for the corrosion which will take place, and which, as a general thing, takes place right in the stop-cock. If the two parts of the box are not separated, so the top section can come and go freely without disturbing the base, then a stone or other material is likely to get in so that even with your rod up where you can get at it, you are not sure of shutting the stop-cock off. It looks to me as though we might devise a box that

will exclude the material from the bottom, which will give the top a chance to rise and fall, and which can be driven down by a man going along the street, without disturbing the bottom of the box.

I have seen one or two boxes which have been brought here by some of the members, one of which comes very close to my idea of what a box should be, except that for use in our soil the top section, which is telescoped onto the lower section, would have to be longer than it is, for it must extend below the frost line in a severe winter. We have a winter once in eight or ten years which is colder than other winters, when we find the frost three and a half to four feet deep. Of course in filled ground it will go down six feet, but that is not a fair ordinary condition. We often go through frost three and a half feet on the south side of a street, and on the north side in our town (I don't know how it is elsewhere) there is certainly from six inches to a foot difference between the depth of the frost there and on the south side of the street. One objection I would have to the box to which I refer is that it simply stands on top of the pipe, and there is no protection against anything working up into the box, and there is no foot on it to give it stability. It should have a flange much larger than that has, so it would have as much holding power as the large base does on the regular gate box. My idea of the stop would be to have the same thing that we have on our mains, a first class gate, with a rod of some substance which would not corrode, and which would give you a chance to put a wrench on it and turn it as easily as you can a faucet. I would like to hear from some of the other members, as to whether they have had any trouble with their service boxes. If I have had it all I won't say anything more about it, but will try to bear it.

MR. GILBERT. I would like to ask Mr. Stacey if he believes it is the best plan to have a rod attached to the shut-off in the sidewalk? I understood him to say that his were arranged in that way.

MR. STACEY. No, sir, I haven't got a rod. I put in two, but I came to the conclusion I wouldn't put in any more. If I put in a rod again I don't think it will be less than seven-eighths of an inch in diameter. (Laughter.)

MR. GILBERT. I would say I never put in but one, and I broke that the first time I tried to use it. Of course we all have trouble enough with the service boxes, and I never have found one yet which I thought was just the right thing. I know the common

Buffalo box in some respects is very good, but the tops, I think, are not made right. If they come up to the top of the ground, as we sometimes use snow plows in our town they are pretty sure to scrape the top off, or if something else heavy runs over them they are pretty sure to be broken, and the small boy, of course, takes delight in taking off the top and filling up the box with stones. It seems to me that some of these manufacturers of water works goods ought to put a little thought upon this subject. Perhaps they may think it is a small thing, but it would save us lots of trouble if they would get us up the right kind of a box. I think, in the first place, they are made too light, so they break too easily. If a wagon runs onto them, with any kind of a load, it is pretty sure to break them, to crush them, and there are many places around the town where that is happening, and we have lots of trouble by their breaking. I have noticed a box in some cities; I never could seem to find out where it was made, or exactly how it was made, only as I could judge from seeing it in the sidewalk; I have noticed it has a large nut in the center, and the top is set in in some way. It seems to me to be a better box than I have ever used, and I would like to inquire if anyone here has ever used a box of that description, and can give me some information about it.

MR. FISH. I have had some experience with boxes, and have tried a good many of them. The conditions in which we use them are perhaps the worst existing in any place you can find in the country. I have found nothing so serviceable as a good heavy 4-inch pipe, a heavy soil pipe, cut off to the proper length and fitted over the pipe, with a cap extending down four or five inches, so it will not be jarred off or worked off, but will lift off freely by getting hold of it. I have had some experience with rods attached to the cocks, and I never put one on unless we had what we call a reverse-cock; that is a plug going in from the bottom, so any pressure coming on top of the rod would loosen it. Then a light rod will be serviceable and work well. This plug is kept in place by the water under the bottom. It is large, fully an inch on the bottom, which gives a water pressure which keeps it up in place, and it will never wedge or get tight, so you can easily loosen it and turn it. As I say, we have got right down to using plain pipe almost entirely.

MR. GILBERT. I have been told by some of the manufacturers of such goods that a box such as I describe would be too expensive.

Now a matter of fifty cents on a sidewalk box is nothing, if they will only give us a better box than these common cheap boxes. The cheapest articles are not always the cheapest in one sense of the word, and I would be willing to pay a proper price for a good service box if I could find one.

MR. FULLER. If we had room at our headquarters, I think it would be a good thing to have a collection of all sorts of service boxes, with a statement of where they are used, and what they cost, and how they are made, and so forth. And, in connection with that, I think it would be a good thing to have samples of different kinds of service pipes, properly labelled as to the length of time they had been in, the conditions of the soil in which they had been placed, and so on. Last night we had a very interesting talk in regard to the different kinds of service pipes, and if the members would contribute samples that they had taken out, and they could be labelled properly, it seems to me it would make a very interesting collection.

[Mr. Stacey brought into the hall a service box belonging to Mr. Holden, which he explained to the convention as meeting his views in some respects, while criticising it in others.]

MR. CHACE. I would not have a center rod on any account. If I shut off a man's water because he doesn't pay his bill, I should expect with that thing there he would find some way to take the cap off and turn the water on himself.

## SERVICE PIPES DEFECTS AND THE REMEDY.

BY GEORGE F. CHACE, SUPT., TAUNTON, MASS.

[*Read Sept.* 8, 1897.]

It may be doubted whether the ideal service pipe has yet been found. No material or combination of materials has thus far proved an unqualified success.

The discussions of this topic at previous meetings of the Association have disclosed the fact that the majority of Superintendents prefer lead for service pipes. Their second choice is cement-lined wrought iron pipe, with a goose neck lead connection between the iron and the corporation cock, for convenience in the fitting and adaptation to the practical difficulties of exact grade.

The obvious objection to lead is the haunting shadow of possible lead poisoning. Experience has, of course, shown that many waters do not act injuriously upon lead, a protective coating being soon formed. Other waters do dissolve the lead, and for such, lead service is unsafe. There is, to the cement-lined iron, an objection which leads me to state some of our Taunton difficulties, hoping to draw out from the experience of others a discussion which may lead to some practical good result.

Small iron pipes not only rust out soon and leak, but often become filled with rust and sediment, to an extent which lessens the flow of water, sometimes so much as to make a service practically useless. Lining the pipes with cement has not, in my experience, wholly removed the evil. However much pains may be taken with the lining, the cement at the connections and at such bends as may occur in the pipe becomes more or less broken, the water comes in contact with the iron, and there is also, between the bronze of the service cocks and the iron of the pipe, a galvanic action, which tends to fill the service cocks with rust and thus stop the passage of water. Formerly the couplings were lined as follows: two nickel plated brass thimbles, like the samples, were put together at their flanges, the inside forming a cylindrical ring for the flow of the

water, and the space between the outside of the thimbles and the inside of the couplings was filled with solder as far as the thread on each end of the coupling.

I have brought for exhibition a sample of a coupling thus prepared for use, and another sample of one taken out from a place where there had been complaint of poor service.

Having found, as will be seen by the rusty sample, such linings of the couplings to be apparently failures, we have abandoned the practice of lining couplings, and use them plain.

I have prepared a record of our work on poor services, for the years beginning with 1892 and ending with 1896. At the end of our financial year, Nov. 30, 1892, we had in use in Taunton, 3,507 services. We had, during the year, 109 cases of poor supply, about 3.1 per cent of the whole number of services.

The majority of these cases were remedied by disconnecting at the stop-and-waste in the cellar, and running a large wire through the service pipe as far as the service cock, and often as far as the corporation cock. When this method failed to make the service clear, the work of the wire was followed by the use of a small pipe of ¼ inch internal diameter. If, on account of the excessively bad condition of the service pipe, or because of too many bends, the above method was fruitless, then the last resort was to dig up the service and clean out the pipe, or in one or two cases, to replace with a new pipe. Of the 109 cases of poor service in 1892, there were 20 where the corporations had to be cleared out, and 8 cases where the whole service was dug up, making in all 28 instances of digging up a part or the whole of a service.

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | of | these | services | had | been | set 15 years or more. |
| 75 | " | " | " | 10 | " | " |
| 8 | " | " | " | only 5 years. | | |
| 1 | " | " | " | less than one year. | | |

Three times, during 1891 and 1892, services were stopped by large eels; twice they plugged up the corporation, and one filled the whole eighteen inches of the lead connection.

They were all alive when found, about three-quarters of an inch in diameter, and from a foot to a foot and one-half long.

The meshes of the screens in use would not allow the passage of a small lead pencil, and the eels could not have passed the valves of the Gaskill pumps. They must have got in when small and

grown in the pipes. It is not surprising that small pipes should fill up in the course of ten or fifteen years, but it would not seem to me that they ought to fill up in five years.

I felt much disturbed during the winter of 1892 to find that we were having so much complaint of poor service. I thought then that one cause of the filling was to be found in the fact that Taunton city water was imperfectly filtered—mixed river and ground water, which contained considerable iron. This gave rise to a growth of crenothrix, which, when in mass, not only has the appearance and effect of iron rust, but is somewhat gummy, and thus readily clogs up the pipes.

We were then in the midst of our work on the Lakeville extension for a new water supply. I therefore hoped that when we should have in use the new supply from the Lakeville ponds we should have less trouble with the services. My hopes were the stronger because the services which we had to clean contained not simply rust but a great deal of sticky muck.

In order to show what the actual facts have been I will give the records of 1893, 1894, 1895 and 1896 in regard to poor services in tabulated form.

Financial year ending November 30, 1893:

| | |
|---|---|
| Number of corporations dug up | 8 |
| Number of whole services dug up | 20 |
| Number of services cleaned out with wire | 48 |
| Number of services replaced by new service pipe | 1 |
| Total number poor services | 77 |

Financial year ending November 30, 1894:

| | |
|---|---|
| Number of corporations dug up | 1 |
| Number of whole services dug up | 10 |
| Number of services cleaned out with wire | 83 |
| Total number poor services | 94 |

On April 5, 1894, the Lakeville water was first supplied to the city. For about two months we still continued to use the old filter basin during the night pumping, but since that time nothing but Lakeville water has been used, except for about one day a year, when we clean the gate-house at Elder's.

Financial year ending November 30, 1895:

| | |
|---|---|
| Number of corporations dug up | 1 |
| Number of whole services dug up | 1 |
| Number of services cleaned out with wire | 30 |
| Total number of poor services | 32 |

Financial year ending November 30, 1896:

| | |
|---|---|
| Number of corporations dug up | 0 |
| Number of whole services dug up | 0 |
| Number of services cleaned out with wire | 26 |
| Total number of poor services | 26 |

The whole number of services in use November 30, 1896, was 3,955, so that the number of poor services was less than .7 of one per cent, against 3.1 per cent in 1892. Moreover, of these 26 cases of poor service—

| | | | | | |
|---|---|---|---|---|---|
| 11 | had been set | 15 | years | or | more. |
| 3 | " | " | 20 | " | " |
| 21 | " | " | 10 | " | " |
| 1 | " | " | 4 | " | " |

This last was on a street where the main had been changed during the year from a 6-inch to a 12-inch pipe, and the service had been supplied during the change through an unlined 2-inch pipe, laid temporarily along the curb. I feel justified from these facts in the belief that the character of the water supply has much to do with the condition of service pipes.

There may even be some disadvantage in using a very pure water. The total average amount of solid matter in the water of Elder's Pond, Lakeville, in 1895 was 2.88 parts per 100,000, while in the filter basin during the same year it was 4.89, and in the river 5.24.

In Taunton, the house cold water pipes are mostly unlined wrought iron. I have known these pipes, since we have used Lakeville water, to be badly rusted in two years. I infer that the less pure water of the past formed a coating on the inside of the iron pipes, thus preventing further corrosion, while the present pure water keeps rusting the exposed surface, especially where there is a constant change of temperature from pipes, through a part of

their course, passing near the furnace in the cellar or near hot water pipes.

I have come to believe that the best service pipe at present in the market is tin-lined iron pipe. It costs more than cement-lined iron, or than lead-lined iron.

But for all-round use, for waters good and bad, soft or hard, it is free from the peril of lead, and it may be hoped that experience will show it to be more trustworthy than cement-lined iron. Time and experience may reduce the cost of the tin-lined iron. I have begun to use it and expect success.

The defects of service pipes are known to all. The remedy seems to be: get the best water supply possible, watch the market for every improvement in service pipes, study your own supply and defects of service, and, by experiment and consultation with brother Superintendents, learn the way to progress and to ultimate perfection.

DISCUSSION.

MR. HAWLEY. We have been having in Atlantic City very much the same experience as the gentleman who has just read his paper has had. I have here a piece of half-inch pipe, which was galvanized once; it is solid now with the accumulations of rust in the past ten years. When the works were first constructed, in 1882, they began to use lead pipe. This was expensive and the people objected to the cost, and the company finally began using galvanized pipe, and its use has been continued until within the past year. During the past year we have renewed 150 galvanized services. It is impossible to clean this pipe after the rust accumulates. We have a total of about 3,700 services, and out of that number we have renewed, as I have said, 150 the past year from curb to main. We have been looking about for something to take the place of galvanized pipe, and I have finally come to exactly the same conclusion which the gentleman who has just read the paper has reached, that tin-lined iron pipe is the best thing on the market for the money. We cannot use lead, because our water is partly swamp water, a considerable amount of vegetable matter in it, which seems to attack the lead, and the Board of Health won't allow us to use it. We are using tin-lined pipe galvanized on the

outside. The lining has proved satisfactory, whereas the coating on the outside of the pipe has not.

MR. FISH. I would like to ask the gentleman if there are electric cars in his city?

MR. HAWLEY. In Atlantic City we have an electric railroad crossing all of our cross-mains, and running parallel to the pipes of the two different systems on Atlantic avenue. We have had absolutely no trouble from electrolysis. The electric road is controlled by the Pennsylvania Railroad Company, and the rails are thoroughly bonded and there is a return conduit to the power station, and this may account for our having no trouble. The only case of electrolysis we have had was on the service which supplied the railroad company's car barn, and at that point the rails, I believe, are not bonded as they are elsewhere. As to the effect of brass and iron, or lead and brass connections in our street connections, we have had no trouble at all.

MR. CHACE. We have electric cars in our city, and I had some fear of electrolysis. Fortunately we had an opportunity two years ago to see whether anything was happening or not, because along two streets where the electric cars run we took up old mains and replaced them with larger ones, and I took pains to look to see if I could find any evidence of any injury to the services or the mains. I am happy to say nothing of the kind was found. The cars had not been running very long, not more than two or three years.

MR. FISH. I have had some experience in this direction. I have been putting in galvanized iron services for thirty years. I have pipes which have been in now for thirty years, and they are still in pretty good condition. I have others that haven't been in three years, which have badly filled up and rusted and have holes in them. In some cases mains have been corroded to that extent that they have burst, and we have had to take them up, and in such cases I have noticed the services have been badly affected. This condition I have attributed to electrolysis. You won't find much trouble in dry ground, but in moist ground electrolysis has a bad effect on the services and the mains. The service pipes will feel it first.

MR. COOK. I would like to inquire how far this was from the power house.

MR. FISH. In one case it was about 1,500 feet. I have had cases in pipe entirely off the line, on a side street, at least 1,000

feet from the street car tracks. The worst trouble I have noticed is where an iron pipe is conected with brass; in fact, that makes a galvanic action of its own.

MR. BANCROFT. I would like to ask Mr. Chace if he has found more defective services on low ground or on high ground, or if he has found them equally distributed?

MR. CHACE. I think there has been more trouble in wet ground, but some were noted on high ground.

MR. GILBERT. I think this is a question we are all very much interested in, and it is rather a hard one to solve. Now, in my experience (and, of course, all of us have had more or less trouble from the filling up of pipes) it has not always been the pipe which filled up first. The fittings, the corporation cock at the main, and also the shut-off in the sidewalk, I have found to be the first to fill up. I think if we would all use a corporation which is finished on the inside and made perfectly smooth, and also a smooth shut-off at the sidewalk, we should do away with a great deal of this trouble. I know that pipe will fill up, as a general thing, in from about 10 to 15 years, but I think if we could avoid trouble in the connections they might last perhaps considerably longer.

More than half of our services are metered where the pipe comes through from the ground into the cellar, and I find considerable trouble with the connections, in the shut-off or between the shut-off and the meter. When a complaint comes to me that a service pipe is not doing its duty, I always look there first. I disconnect the meter, and very often I find the shut-off all filled up. And I might say in four cases out of five there wouldn't be a hole through as large as the small end of a pipe stem. Of course the service wouldn't be very satisfactory with the fittings filled up like that. After clearing this out, if we don't get the proper pressure, then we run a wire through, as has been stated here by the gentleman in his paper, as far as the shut-off at the sidewalk and clear it there; and if that does not produce the right effect we dig it up at the main, and there in most every case I find the same difficulty that I found back of the meter in the cellar, that the connection has filled up.

We have used cement-lined service pipe, and that, as we all know, will not fill up as quickly as an iron pipe. We never have used galvanized pipes at all. We have laid some lead, but, as the gentleman from Atlantic City has said, so our Board of Health would

not allow us to lay it. We did lay a litttle of the lead-lined pipe, but they would not allow us to lay that, and so we have continued with the cement-lined pipe. Now I am very careful about the corporation, and I have the sidewalk cock made with a full finished hole also. Many people, where they have their piping in the cellar done outside of the water works department, use these cheap shut-offs which have an oblong hole through them and unfinished, and there is no part of the service pipes which will fill up so quickly. In my opinion we should be very careful to use nothing for a shut-off or corporation that hasn't a finished surface on the inside.

MR. RICHARDS. Some 12 or 15 years ago I investigated this matter of service pipe carefully, and embodied the result of the investigation in a paper which I read before the Association. The conclusion I arrived at then was that lead was the best and the cheapest service pipe, except in exceptional waters; and I have seen no reason yet to alter that determination. As regards tin-lined iron pipe, the pipe which was made at that day under a patented process was made by expanding a tube of tin inside the iron pipe. I don't know how it is made at present.* But the result of the use of that was that water penetrated around the end of the tin tube, rust formed between the tin and the iron, compressed the tin tube in the pipe, and filled it up. The conclusion I arrived at then was that tin-lined iron would not do. We have used lead continuously with very satisfactory results.

MR. BANCROFT. I remember but three cases where service pipes on our works have been clogged up. The first one was a long iron cement-lined pipe—I think the service was about 150 feet in length. This became clogged and was cleaned out with a wire, as has been described, but it closed up again. The pipe was then taken out and was found to be nearly filled, while the sidewalk cock and the corporation were entirely free. A lead-lined service pipe was laid in the place of this cement-lined pipe, and after a period of possibly a year, complaints came in again that there was no flow of water through the service. That was dug up and was found in about the same condition that the cement-lined pipe was in. Those were both three-quarter inch pipes—that is, the cement pipe was one inch lined

*The manufacturer of tin-lined pipe desires the editors to say that the pipe as at present manufactured is superior to that referred to.—*Editors.*

with cement, making a three-quarter pipe. I took out the lead-lined pipe and put in an inch and a quarter galvanized pipe, thinking I would have a pipe large enough so as to allow room for some filling up. That pipe has been in service now about two years, and we have had no complaints from it. It is on about the lowest ground we have, I think, in fact, it is the lowest service we have.

Another pipe, which was of lead, a long service, as I remember it, was about 200 feet, has been closed up and cleaned twice, I think, by the use of the wire, and it is still in service.

MR. FISH. Two years ago, I think it was, some member of this Association made a statement of an experience of his, where he had put in three service pipes about the same time, side by side, one of which filled up and gave a great deal of trouble, while the other two remained perfectly clear. These pipes were neighbors, within about 200 feet of each other, and were all galvanized pipes. I think it was the gentleman from Burlington who made the statement, and he raised the question whether there was not something in the quality of the iron itself which might account for the results. It seemed a very strange thing to me at that time, and it did not agree with my experience. I would like to know if any gentleman here has thought anything more of the subject since then, or has ascertained whether one kind of iron has a different capacity for filling up than another. The gentleman from Burlington stated his experience very clearly, but there was not much discussion of the matter at that time, because we were about adjourning for dinner, which seemed to be more important just then than closed up pipes.

MR. GILBERT. A year ago last winter I had a service which commenced to leak, and I had it dug up near the house, and found it leaked there. We put in a new shut-off, and still it kept leaking, and we finally dug up the whole service from the house to the street. The pipe had been laid about five years, and I found it was full of holes from one end to the other. It was laid in low ground, where it was wet nearly the year round, but it was not on any street where electricity could have had anything to do with it at all. I could account for its condition in no other way than by laying it to the kind of iron of which the pipe was made.

MR. FISH. I think the gentleman may have been mistaken in his conclusion that electricity could not have had anything to do with it. It is not necessary that a pipe shall be near a line of street

cars in order to be affected by the electric current. If the cars run on the line of a main pipe anywhere, it may take an offset and follow the main pipe around. I have known cases where that has happened. I do not think there is much trouble to be feared from electrical corrosion if the connections between the rails are kept good, but there may be an off-set of 1,000 feet, or 2,000 feet with a poorly laid road.

MR. RICHARDS. I will say that sometimes, if a service pipe is laid in a street which has been filled in with coal ashes, the ashes will "beat electricity out of sight" in eating up the pipe. That happens once in awhile.

MR. NAYLOR. About four years ago I laid some tarred pipe in a wet place, and about two months ago I had a burst in it and took it up. I found the pipe entirely eaten away. In some places for a couple of feet it seemed to be all eaten from the outside. In another locality I ran across a piece of pipe of this same kind, which was laid 18 years before, and it was just as fresh as if it was newly laid. This was upon a hill, where everything was dry. So it seems to me that a good deal depends upon the ground that the pipes are laid in. It is our experience in Maynard that our pipes rust from the outside quicker than from the inside. We do not seem to have any trouble with the inside of cement-lined pipe, but we have a good deal of trouble with the outside.

MR. PORTER. It seems to me it would be interesting to know if anyone else has had experience with defects in the use of tin-lined iron pipe, because, even if this is not the ideal pipe, it seems to promise very well for use in special cases. I know I put it into my own house, in a case where, perhaps, it was unnecessary, as a precaution, as we had had a very unfavorable experience in the family with the use of lead pipe, and we desired to avoid every possibility of danger that we could. If there are weaknesses in the use of this pipe, such as have been spoken of, I think it would be very desirable to have them made known.

THE PRESIDENT. If anyone can answer Mr. Porter's question from experience, we would like to hear from him now. Our experience with tin-lined pipe is rather limited. Personally I know nothing about it, for I haven't used any of it, and it is comparatively new. Apparently there is no one here who has had experience with it long enough to state anything about it.

MR. BANCROFT. We have been using lead-lined pipe for three years. We haven't used any tin-lined on services, although I have put some of it into my own house. We have never had any trouble with the lead-lined pipe, such as has been spoken of as occurring with the tin-lined. I don't know why it should not apply to one as well as to the other, and I suppose the process of lining with tin is the same as the process of lining with lead at the present time.

MR. RICHARDS. I will say the pipe I referred to was made, my impression is, some 10 or 15 years ago, by New York parties, who made a specialty of tin-lined iron pipe at that time. Whether it was made in the same manner that tin-lined iron pipe is made at present I do not know, but that was made by expanding a tube of tin inside of the iron pipe. The result of using it was as I have stated, and in quite a number of cases it had to be taken up.

MR. BEALS. Why should not the same experience be had with tin-lined iron pipe as with block tin, regardless of the iron? I have had some experience, not in connection with our water works system, but with one or two wells in town, before we had our system of water supply, where the parties thought they would get the best thing they could and selected block tin. In two years the pipe was so honeycombed they could not pump water through it; they pumped air. I wonder if they would not be liable, with the same water, to get the same result in the use of tin-lined iron pipe—that is, that the tin would honeycomb and the water would go through it and rust the iron.

It seems to me there must be some difference in plain iron pipes. I have in mind now a service—our regular service pipes are cement-lined iron—I have in mind a house which was piped, after the service was in the cellar, with plain black iron pipe, and I have had complaints enough from that this year to make a superintendent run mad almost, of the quality of the water in that service. The woman of the house said it was so poor she could not use it; she had tied a cloth over the faucet and had tried to filter it in all ways, but she had to go to her neighbor's to get water she could use. Now, the neighbor's house was piped with the same class of pipe, plain iron. Well, the owner of the building finally took out the old piping entirely and put in new iron pipe, and the lady of the house comes around and says the water is tip-top. Now, it seems to me

there must be some difference in iron pipe, because there are two houses within 200 feet, both piped with plain iron, and in one case the water was so bad that the people had to go to the other house to get their water, and when the old pipe was taken out and new put in there was no further trouble.

MR. HAWLEY. When this matter of a change in the material for services came up last spring, in conversation with some of the plumbers I was told by one of them that he had used some tin-lined pipe 10 or 12 years ago, and at my request he took out several pieces of the pipe and showed it to me. I don't know the process by which that was manufactured, I don't know who manufactured it, or where it came from, but the tin was in perfect condition, while the iron was somewhat corroded from the outside where it had been in the ground. I based my recommendation of tin-lined pipe on that. Now, as to the difference in iron pipes. There is unquestionably a difference in quality. I know of services today in Atlantic City that have been in 10 or 12 years which are still very satisfactory; and I know of other services of the same size, which have been in less than half the time, which have completely filled, or practically so. I have seen a ¾-inch galvanized pipe which has been in four years and a half so filled up it had less than the capacity of a ¼-inch pipe, and I have seen other services of the same kind, which have been in longer than that, where the pipe is still comparatively free.

MR. BANCROFT. As the question of electrolysis has been brought up here, I would like to inquire if anybody can tell how small a voltage on a pipe line will do damage to pipe, either to a main or services?

THE PRESIDENT. I would answer the gentleman's question by saying that a little was bad and a good deal was worse. We have heard considerable about lead-lined pipe being injurious to health, or I take it that that is what has been meant. Now, Mr. Richards has lived in a city, and has had charge of the water works there, and in his long experience there has been no trouble from the use of lead-lined pipe. There are other gentlemen here who have felt serious ill effects from its use right in their own families. This would seem to show conclusively that lead-lined pipe may be affected by some waters and not affected by others. I used to feel a good deal of fear about the use of lead-lined service pipe, but I have been

getting over that fear lately, from the fact that the authenticated cases of poisoning from its use have received so little prominence. If there is anybody here who has a well authenticated case of poisoning from water through a lead-lined pipe, I should like to hear a little something in that direction.

MR. NAYLOR. When a gentleman of our town built his house he had a driven well and put in a very heavy lead pipe. The members of his family have been sick more or less ever since, and there have been a number of deaths. At one time, after our water works were put in (his house was a considerable distance from our main pipe), he ordered his machinist to come up and see what was the trouble with his pump. They kept fixing the pump and fixing it, and finally they came to the conclusion the trouble was not above but below, for whatever they did they couldn't make the pump work. So they got down into the well, and when they got there so as to get hold of the pipe, it crushed right up. The water had eaten the lead pipe entirely away so there was nothing left but a shell which was all full of holes. He was satisfied that the water had eaten the lead and they had drunk it. So he sent for me and wanted to know how soon I could get our water into his house, for he didn't want to drink another drop out of the well. We put the water in, and I believe they have had better health as a family since they stopped using well water through that lead pipe.

THE SECRETARY. What sort of a pipe are they drawing their water through now?

MR. NAYLOR. They are drawing the water through a 4-inch iron pipe, cement-lined, into the cellar, and tarred iron pipe up to the sink.

MR. RICHARDS. I agree with you, Mr. President, that I should like to know of a well authenticated case of lead poisoning from the use of a lead service pipe. I know of cases of poisoning from a pipe running from a well, from a spring and from a lead-lined tank, and other similar cases, but I never heard of a case in connection with a service pipe running from a water main into a house, and I have never seen a description of such a case anywhere in this country, although I have looked for them continually. And I doubt very much if there ever has been a case of lead poisoning from a service pipe extending from a water main into a house and constantly filled with water, unless the water was of exceptional quality.

We are talking about service pipe now, and not talking about pipe from wells or pipe from springs, which is a different thing entirely.

MR. HAZEN. I would refer the gentleman to the reports of the English local government boards for a good many hundreds of cases. In some of the English cities, notably Sheffield, where the water is a surface water from reservoirs, distributed through iron mains and lead service pipes, the water occasionally becomes acid and takes up the lead from the service pipes in quite large quantities; and there have been, not single cases, but hundreds and thousands of cases of lead poisoning at those times. The remedy which has finally been adopted is to treat the water in a certain way to remove the acid and make it alkaline, and when that is done the trouble from the solution of the lead disappears.

A MEMBER. This question has been brought up in a manner which would tend to make us ask for more correct information than we have had on this subject. We have used in our works lead pipes for over 50 years, and have had no trouble whatever from any defect on the inside of the pipe. They have been eaten on the outside, where they have been laid in coal ashes, or certain kinds of clay. I think it would be a matter of useful information to the members of this Association if gentlemen who have used lead pipes on their works would communicate their experience to the Secretary, for if there are any injurious results from the use of lead pipe, we ought to know it and in an authentic manner.

MR. BANCROFT. In my remarks before I stated we were using lead-lined pipe for service pipe, and that I had used a tin-lined pipe in my own house. I did not use tin-lined pipe from any fear of the lead-lined pipe, but for the purpose of experimenting with the tin-lined.

MR. PORTER. I have used tin-lined pipe somewhat for the same reason that the gentleman has just stated, but partly also as a precaution. The unfortunate experience to which I alluded a while ago was this—that a member of our family died a few years ago from illness which was declared by an able physician to be unquestionably the result of lead poisoning, and several other members of the family appeared to have been affected by it also. This was shown by analyses by Prof. Wood, of the Harvard Medical School. Now, the source of that poisoning was never known with certainty, but it was supposed in the case of the person who died to have been

in water from a spring in the country, which was carried through about 700 feet of small lead pipe to the house; but it was running continuously, never stopped. In the case of city service pipes I suppose, from all I have heard and read, that there is ordinarily very little danger, but I suppose there may possibly be some danger from the use of the water by a servant in the morning from pipes in which it has been standing all night long. Practically that is a very slight danger, but I think it is one perhaps worth considering.

# PROCEEDINGS OF THE SIXTEENTH ANNUAL CONVENTION.

NEWPORT, R. I., September 8, 9, 10, 1897.

The headquarters of the Association during the convention were at the Ocean House, and the sessions of the convention were held in the large parlor of the hotel.

## WEDNESDAY, SEPTEMBER 8, 1897.

The convention was called to order at 11.50 a. m. by President Haskell.

On motion of Mr. Holden the reading of the minutes of the last meeting was dispensed with.

The President introduced His Honor Patrick J. Boyle, Mayor of Newport, who spoke as follows:

### ADDRESS OF WELCOME BY MAYOR BOYLE.

*Mr. President and Members of the New England Water Works Association, Ladies and Gentlemen:*

It affords me much pleasure to meet you today and bid you welcome to our city. We assure you that we are much gratified to have with us the representatives of that business or profession that has done so much in the past, and will, we hope, do so much more in the future for the common good. I assure you that we are very much pleased to have you here, but the welcome which I extend to you must at the best seem, I am afraid, rather a cool one. We unfortunately (with all due respect to the wisdom of the early founders of this city of ours) live under a charter which prohibits the city government from appropriating money for the purposes of entertaining such bodies as yours. I simply call your attention to this fact in order that you will understand that we do not lack appreciation of your coming, and regret that as a city we are unable to take fitting recognition of your presence.

Coming as you do from different parts of New England, you must be acquainted with the many attractions in Newport, and I there-

fore will not detain you from your business by any reference to them. I hope that your deliberations will result in the improvement of the sanitary condition of your respective communities, and I sincerely trust (and I think I have my fellow citizens with me when I say it) that your deliberations will result in some improvement in our local water matters here.

Ladies and gentlemen, I hope you will have a pleasant time while you are with us, and that when you leave us you will take home with you many pleasant recollections of your visit. (Applause.)

RESPONSE BY PRESIDENT HASKELL.

*Mr. Mayor:*

In behalf of the New England Water Works Association I desire to thank you for your friendly interest in our welfare, and to extend to you and to the citizens of Newport a cordial invitation to attend our meetings.

It has long been the desire of the members of this Association to visit this beautiful city, situated on the picturesque shores of Narragansett bay, and abounding as it does in so many natural and historical objects of interest, enhanced by the lavish display of art, made possible by the possession of great wealth. Although it has always been the object of these meetings to add to our fund of useful knowledge in all that appertains to the proper conduct of a water supply, it has been our custom in the past to devote a portion of our time to recreation, assembling, as we have done, in different cities from year to year, and visiting the principal objects of interest to be found in the immediate vicinity. While our stay with you will be short, I do not doubt that our members will avail themselves of every opportunity to its utmost.

The convention then proceeded to the regular order of business.

ELECTION OF NEW MEMBERS.

The Secretary presented the following list of applicants for membership, with the approval and recommendation of the Executive Committee:

RESIDENT ACTIVE.

**Frank S. Bailey, Assistant in City Engineer's Office, Brockton, Mass.; John D. Adams, Water Commissioner and Superintendent, Provincetown, Mass.; Thomas H. Rogers, Pumping Engineer for the Pennichuck Water Works, Nashua, N. H.**

NON-RESIDENT ACTIVE.

Harry A. Lord, Superintendent, City Water Works, Ogdensburg, N. Y.; W. C. Hawley, Superintendent Water Department, Atlantic City, N. J.; Robert S. Weston, First Assistant Chemist, Louisville Experiment Station, Louisville Water Co., Ky.

ASSOCIATE.

Lead Lined Iron Pipe Co., Wakefield, Mass.; W. K. Helmer, Agent Holly Manufacturing Co., Lockport, N. Y.; Kennedy Valve Co., 75 John St., New York.

On motion of Mr. Fuller, the Secretary was empowered and directed to cast the vote of the Association in favor of the applicants, which he did, and they were declared by the President elected to membership.

The President then delivered his annual address.

## ADDRESS OF PRESIDENT HASKELL.

*Gentlemen of the New England Water Works Association :*

We are now assembled to hold the sixteenth annual convention of this society. The usual time for our annual meeting is in June.

The reasons that led to the adoption of this later date were the better facilities afforded for our accommodation here, and that many of our members can better afford to take this time to be absent from their routine of duties.

Since our last meeting, death has removed from our membership: Albert F. Noyes, Civil Engineer, Boston, Mass.; Richard R. Yates, Superintendent, Northboro, Mass.; Jos. A. Lakewood, Superintendent, Yonkers, N. Y.; Charles B. Brush, Engineer and Superintendent, Hackensack Water Co., Hoboken, N. Y.; Jas. Hugh Stanwood, Prof. Civil Engineering, Institute Technology, Boston, Mass.; Ezra Clark, President and Superintendent, Hartford, Conn.; Wm. E. Nason, Superintendent, Franklin, Mass.; Wilmer Reed.

Among their number the most familiar countenance was that of Mr. Noyes, a former president of this Society, and also an ex-president of the Boston Society of Civil Engineers. His genial presence and hearty interest in our welfare displayed at all of our meetings will be sadly missed.

Our membership is still increasing; we now have 464 Active, 80 Associate, and 5 Honorary members, a total of 549. We must, however, bear in mind that numbers alone do not constitute the greatest strength, but that the best results can only be secured by

earnest work on the part of those who, having valuable knowledge, are willing to contribute it for the benefit of others.

The principal good to be derived from this Association is to be gathered from the papers contributed and the opportunity afforded for the discussion of any points not fully understood.

Our regular meetings have been well attended and a lively interest was shown in the various papers presented.

On September 9th, 1896, the Society visited the Hobbs Brook Reservoir, a new addition to the Cambridge Water Supply, containing 2,000,000,000 gallons storage capacity. Under the guidance of Mr. L. M. Hastings, the City Engineer of Cambridge, an opportunity was given to inspect the method of construction employed in building the lower dam, and the extensive removal of soil and muck from the bed of the reservoir, which was being excavated five feet, whenever that depth of soil was found, necessitating the removal of 1,900,000 cubic yards of material.

On June 9th, 1897, a visit was made to the Metropolitan Water Works at Clinton, where a reservoir is to be built for the Metropolitan district of 63,000,000,000 gallons storage capacity.

Under the guidance of Chief Engineer Stearns and Deputy Engineers Richardson and Miller, the party proceeded over the site of the reservoir through a portion of the tunnel and along the line of conduit to the bridge upon which the conduit crosses the Assabet river.

These excursions to works of such magnitude, presented many instructive features. A severe rainstorm interfered somewhat with the pleasure of each day.

During the most intense heat of the summer our permanent headquarters in the Tremont Temple supplied us with a cool and comfortable place in which the current magazines of the day and a library containing an extensive fund of information on the subject of Water Works could be examined. Our short experience in its occupancy has fully demonstrated its value.

As we look over the problems presented in procuring a water supply for a large city, the question of the purity of the water furnishes a subject of vital interest to all. All will admit that pure water is necessary for the preservation of health. Many instances can be cited in recent years where efforts to improve the quality of water supplied has reduced the death rate of a community in a marked degree.

The remarkable discoveries made by medical science of recent date have shown more fully than was possible in the past, the intimate relation that water bears to perfect health.

These undeniable facts present to us most forcibly the question of water purification. The experience of the past shows us most conclusively that natural ponds cannot be depended upon at all times to furnish pure and wholesome water, and that artificial reservoirs are still more unreliable. The solution of this problem will undoubtedly be reached at a no distant date, through Legislative enactments making the thorough filtration of all surface water supplies compulsory.

It is with feelings of deep regret that I announce the resignation of Mr. Allen Hazen, the senior editor of the JOURNAL, who will not be able in the future to fulfil the duties of that office.

In conclusion I desire to thank all who have assisted me in the effort to make our meetings interesting and instructive.

The Treasurer then submitted his annual report as follows :

## REPORT OF THE TREASURER.

*George E. Batchelder, in Account With the New England Water Works Association.*

RECEIPTS.

| | | | |
|---|---|---|---|
| 1896. | Balance on hand as per last report : | | |
| | People's Savings Bank | $1,052.64 | |
| | City National Bank | 416.74 | |
| | Safe Deposit and Trust Co | 1,235.07 | |
| | | | $2,704.45 |
| July 21. | Received from J. C. Whitney, Secretary | $ 700.00 | |
| Dec. 30. | " " " " | 400.00 | |
| 1897. | | | |
| Jan. 8. | " " " " | 200.00 | |
| " 19. | " " " " | 300.00 | |
| " 29. | " " " " | 250.00 | |
| Mch. 1. | " " " " | 300.00 | |
| May 11. | " " " " | 300.00 | |
| June 1. | " " " " | 300.00 | |
| " 3. | " " " " | 300.00 | |
| " 8. | " " " " | 150.00 | |
| | | $ | 3,200.00 |
| Aug. 1. | People's Savings Bank, interest | $ 63.76 | |
| Sept. 1. | Safe Deposit and Trust Co., interest | 69.47 | |
| " 1. | City National Bank, interest | 7.00 | |
| | | $ | 140.23 |
| | | | $6,044.68 |

EXPENDITURES.

| | | | |
|---|---|---|---|
| 1896. | | | |
| June | 12. | James T. Almy, badges | $ 8.96 |
| " | 12. | Frank De Silva, lettering door of headquarters | 1.86 |
| " | 12. | Newton Journal, printing circulars and postals | 16.50 |
| " | 12. | A. T. Thompson & Co., lantern service, Lynn | 22.70 |
| " | 15. | Alfred Mudge & Son, printing postals, etc | 8.00 |
| " | 16. | Irving & Casson, upholstering two chairs | 40.00 |
| " | 24. | Bacon & Burpee, reporting Lynn meeting | 75.00 |
| " | 30. | Fanning Printing Co., printing envelopes | 3.00 |
| July | 1. | Thos. Campbell, 2d, table for Lynn meeting | 5.02 |
| " | 1. | Electro-Light Engraving Co., electro for adv | 1.08 |
| " | 14. | Newton Journal, printing envelopes, circulars and postals | 9.00 |
| Aug. | 2. | The Oxford Club, Lynn, hall for June meeting | 55.00 |
| Sept. | 1. | J. C. Whitney, stamps, stationery, express, telegrams, telephone, etc | 99.31 |
| " | 1. | J. C. Whitney, salary to Sept. 1, 1896 | 125.00 |
| " | 4. | Miss A. B. Knowlton, typewriting | 14.00 |
| " | 18. | The Heliotype Printing Co., plates and half tone plates | 51.18 |
| Oct. | 1. | Stephen F. Cate Estate, barges for Sept. meeting | 22.00 |
| " | 10. | The Heliotype Printing Co., two half tone plates | 6.00 |
| " | 12. | W. H. Richards, salary to Sept. 1, postage, freight, express, etc | 86.03 |
| " | 15. | Boston Society of Civil Engineers, rent of rooms to Sept. 1, 1896 | 150.00 |
| Nov. | 2. | Mrs. A. D. Wood, basket of roses | 10.00 |
| " | 24. | Alfred Mudge & Son, printing June Journal | 294.80 |
| Dec. | 8. | Electro-Light Engraving Co., five half tones engineering constructions | 28.31 |
| " | 11. | The Heliotype Printing Co., one zinc plate | 1.68 |
| " | 12. | J. C. Whitney, express, freight, telegrams, telephone, etc | 15.40 |
| " | 12. | J. C. Whitney, salary to Dec. 1, 1896 | 125.00 |
| 1896. | | | |
| Dec. | 14. | W. H. Richards, salary, telegrams, telephone, express, typewriting, etc | 99.69 |
| " | 14. | The Heliotype Printing Co., 850 copies each two diagrams and one map | 39.00 |
| " | 31. | Alfred Mudge & Son, printing September Journal | 183.00 |
| 1897. | | | |
| Jan. | 1. | Boston Society of Civil Engineers, rent of rooms to Jan. 1, 1897 | 100.00 |
| " | 25. | Newton Journal, printing circulars, etc | 9.00 |
| Feb. | 24. | The Heliotype Printing Co., 870 copies plan of New Bedford Water Works | 17.50 |
| | | Amount carried forward | $1,723.02 |

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|---|---|---|---|---|
| | | Amount brought forward | $1,723.02 | |
| Feb. | 26. | The Heliotype Printing Co., five half tone plates. | 27.60 | |
| Mch. | 8. | Newton Journal, printing circulars and envelopes | 21.50 | |
| " | 11. | Bacon & Burpee, report of winter meeting | 75.75 | |
| " | 15. | The Heliotype Printing Co., one half tone plate | 5.52 | |
| " | 26. | W. H. Richards, postage, express, telegrams, typewriting and salary to March 1 | 99.96 | |
| " | 27. | J. C. Whitney, back numbers of Journal, express, telegrams, typewriting, etc | 116.60 | |
| " | 27. | J. C. Whitney, salary to March 1, 1897 | 125.00 | |
| " | 31. | Fanning Printing Co., 850 half tones of A. F. Noyes | 5.00 | |
| Apr. | 7. | Alfred Mudge & Son, printing December Journal. | 191.75 | |
| " | 8. | The Heliotype Printing Co., one half tone plate | 5.52 | |
| " | 10. | The Heliotype Printing Co., one zinc plate map | 2.60 | |
| " | 14. | The Heliotype Printing Co., one half tone pencil drawing | 5.06 | |
| " | 21. | The Heliotype Printing Co., three half tone plates | 16.56 | |
| May | 21. | Allen Hazen, services of assistant, express and telegrams | 34.50 | |
| " | 24. | Electro-Light Engraving Co., one eng. diagram | 1.04 | |
| " | 27. | The Heliotype Printing Co., 3,050 copies plans water filter at Ashland, Wis | 28.50 | |
| June | 1. | Boston Society of Civil Engineers, rent to June 1, 1897 | 150.00 | |
| " | 7. | W. H. Richards, salary to June 1, 1897, postage, express, etc | 84.56 | |
| " | 7. | J. C. Whitney, postage, express, typewriting, travel, etc | 19.97 | |
| " | 7. | J. C. Whitney, salary to June 1, 1897 | 125.00 | |
| July | 3. | Alfred Mudge & Son, printing March Journal | 384.83 | |
| " | 3. | W. H. Richards, postage, express, telegrams, telephone, etc | 35.85 | |
| Aug. | 28. | Alfred Mudge & Son, 900 copies and 800 slips of three cuts and rebinding 100 pamphlets | 8.25 | |
| " | 28. | Newton Journal, printing postals, receipts and circulars | 7.25 | |
| " | 28. | J. C. Whitney, back numbers of Journal | 21.75 | |
| | | | | $3,322.94 |

BALANCE ON HAND.

| | | | | |
|---|---|---|---|---|
| Aug. | 1. | People's Savings Bank | $1,116.40 | |
| Sept. | 1. | Safe Deposit & Trust Co | 1,377.48 | |
| " | 1. | City National Bank | 227.86 | |
| | | | | $2,721.74 |
| | | | | $6,044.68 |

Respectfully submitted,

GEORGE E. BATCHELDER, *Treasurer.*

Examined, audited and found correct.

A. R. HATHAWAY,
A. W. F. BROWN, } *Finance Committee.*

September 4, 1897.

On motion of Mr. Beals, the report of the Treasurer was accepted and placed on file.

On motion of Mr. Holden, the report of the Auditing Committee was accepted and placed on file.

The Secretary submitted the following as his report:

## REPORT OF THE SECRETARY.

*Summary of Statistics Relative to Membership for Year Ending June 1,'97.*

ACTIVE MEMBERS.

| | | | |
|---|---|---|---|
| June 1, 1896, total active membership | | 442 | |
| Withdrawals during the year | | 11 | |
| | | 431 | |
| INITIATIONS: | | | |
| June, 1896 | 15 | | |
| December, 1896 | 6 | | |
| January, 1897 | 2 | | |
| February, 1897 | 5 | | |
| March, 1897 | 5 | | |
| | | 33 | |
| June 1, 1897, total active membership | | | 464 |

HONORARY MEMBERS.

| | | | |
|---|---|---|---|
| June 1, 1896, total honorary membership | | 5 | |
| June 1, 1897, total honorary membership | | — | 5 |

ASSOCIATE MEMBERS.

| | | | |
|---|---|---|---|
| June 1, 1896, total associate membership | | 82 | |
| Withdrawals during the year | | 6 | |
| | | 76 | |
| INITIATIONS: | | | |
| June, 1896 | 1 | | |
| December, 1896 | 2 | | |
| January, 1897 | 1 | | |
| | | 4 | |
| June 1, 1897, total associate membership | | | 80 |
| June 1, 1897, total membership | | | 549 |

A gain for the year of 20.

*Summary of Receipts for the Year Ending June 1, 1897.*

| | Dr. | |
|---|---|---|
| Received for advertisements | | $ 1,355.00 |
| " initiation | | 166.00 |
| " annual dues | | 1,508.00 |
| " Journals | | 149.00 |
| " miscellaneous | | 22.00 |
| | | $3,200.00 |

Cr.

| | | | |
|---|---|---|---|
| 1896. | | | |
| July 20. | Paid Geo. E. Batchelder, Treasurer | ..... | $ 700.00 |
| Dec. 30. | " " | ..... | 400.00 |
| 1897. | | | |
| Jan. 8. | " " | ..... | 200.00 |
| Jan. 18. | " " | ..... | 250.00 |
| Jan. 27. | " " | ..... | 300.00 |
| Mch. 8. | " " | ..... | 300.00 |
| May 10. | " " | ..... | 300.00 |
| May 29. | " " | ..... | 300.00 |
| June 2. | " " | ..... | 300.00 |
| June 7. | " " | ..... | 150.00 |
| | | | $3,200.00 |

On motion of Mr. Beals, it was voted that the report be accepted and placed on file.

AFTERNOON SESSION.

Edward V. French of Boston opened the afternoon session by reading a paper entitled "Loss of Pressure Caused by Meters on a Factory Fire Supply." The paper was discussed by the President, Mr. Fish, Mr. Walker and Mr. Fuller, and in answer to suggestions by them, Mr. French explained more fully certain matters considered in his paper.

The next paper was by Frank L. Fuller of Boston, and related to "Sinking Funds." The President and Messrs. Smith, Gilbert, Beals and Hawley took part in the discussion which followed.

Henry A. Cook, Supt., Salem, Mass., was announced upon the program to speak upon "The Water Supply of Salem." Mr. Cook announced that he had not had opportunity to prepare a paper, but at the request of certain members of the Association he exhibited two tools which he had found convenient to use in his work. One was a very ingenious electric lighting arrangement, which can be easily carried by the workman, used for examining the interior of a service box. The other was an appliance for removing an obstruction, like a small stone, from a service box.

EVENING SESSION.

At the evening session George C. Whipple, Biologist and Director of the Mt. Prospect Laboratory, Brooklyn Water Department, Brooklyn, N. Y., read a paper entitled "Some Observations on the Growth of Organisms in Water Pipes." Messrs. Fuller, Chace and the President took part in the discussion.

George F. Chace, Supt., Taunton, Mass., read a paper on "Service Pipe Defects and the Remedy." There was a long discussion upon this paper, participated in by Messrs. Fish, Bancroft, Hawley, Gilbert, Richards, Naylor, Porter, Beals and Hazen.

Mr. Hazen presented to the convention Mr. Nicholas Simin, Chief Engineer of the water works of Moscow, Russia, who, he said, had come a very long distance to attend the meeting of the Association, and he trusted the members would give him a cordial welcome. Mr. Simin was received with loud applause. He responded in his native language. [The following translation of what he said was kindly furnished by his daughter, who, with a lady friend from Moscow, is accompanying Mr. Simin upon his tour in this country:]

*Ladies and Gentlemen:* I am very glad to be among you in your beautiful country. America is a country where people know how to approach each question bravely, and rapidly to come to its solution, conquering all the hindrances met on the way. In America it is not only spoken of things, but it is done, and done quickly, without delay.

The progress of the technique is here astonishing. The water works art, for the study of which I came here, has received in your country an immense development, which answers perfectly well to all the requests put by science and by life.

Gentlemen, I thank you heartily for your amiable attention, and I welcome you as intelligent representatives of the water works art of your great country. (Loud applause.)

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THURSDAY, September 9th.

At the morning session Mr. Byron I. Cook, Superintendent, Woonsocket, R. I., read a paper entitled "Reservoir and Dam No. 3, Woonsocket Water Works." The paper was discussed by Messrs. Stacey, Chace and Hazen, and the President.

Mr. George A. Stacey, Superintendent, Marlboro, Mass., spoke on "Service Boxes," and was followed by Messrs. Gilbert, Fish and Fuller.

Mr. Henry F. Jenks of Pawtucket, R. I., who had charge of the exhibit of associate members, presented his report.

Mr. W. C. Hawley, Superintendent, Atlantic City, N. J., then addressed the convention, giving the results obtained by the use of water meters at Atlantic City.

In the evening Mr. Frederick P. Stearns, Chief Engineer of Metropolitan Water Board, gave an illustrated talk on the "Metropolitan Water Supply of Massachusetts."

He was followed by Mr. H. F. J. Porter with a talk on "Steel Forgings," illustrated by stereopticon views of the machinery and interior of the shops of the Bethlehem Works, and the processes of manufacture.

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FRIDAY, September 10th, 1897.

The first business was the election of new members. The Secretary read the following names of applicants, duly approved and recommended by the Executive Committee:

RESIDENT ACTIVE.

Arthur F. Estabrook, Water Commissioner, Leicester, Mass.
E. V. French, Civil Engineer, Boston, Mass.
J. B. Putnam, Superintendent, Westboro, Mass.
Franklin H. Robbins, Civil Engineer, Boston, Mass.
J. A. St. Louis, Water Registrar, Marlboro, Mass.
Chas. W. Sherman, Civil Engineer, Boston, Mass.

NON-RESIDENT ACTIVE.

Geo. B. Bassett, Civil Engineer, Buffalo, N. Y.
A. D. Clark, Secretary Water Company, Kane, Penn.
Wm. H. Dean, Analyst, Wilkesbarre Penn.
A. S. Gear, Superintendent, Supply Yards, New York City, N. Y.
Harvey M. Geer, Civil Engineer, Ballston Spa, N. Y.
James H. Harlow, President Pennsylvania Water Company, Wilkinsburg, Penn.
Hibbert Hill, Biologist Laboratory Brooklyn Department of Health, Rockville Centre, Long Island, N. Y.
Emil Kuichling, Chief Engineer, Water Works, Rochester, N. Y.

ASSOCIATE.

Buffalo Meter Company, Water Meters, Buffalo, N. Y.
B. F. Smith & Bros., Driven Wells, Boston, Mass.

On motion of Mr. Fuller, the Secretary cast the ballot of the Association in favor of the applicants, and they were declared elected.

## ELECTION OF OFFICERS.

Mr. Coggeshall, for the Nominating Committee, reported the following list of officers for the ensuing year:

PRESIDENT.

WILLARD KENT, Manager Water Company, Narragansett Pier, R. I.

VICE-PRESIDENTS.

MELVILLE A. SINCLAIR, Superintendent, Bangor, Me.; CHARLES K. WALKER, Superintendent, Manchester, N. H.; F. H. CRANDALL, Superintendent, Burlington, Vt.; JOSEPH G. TENNEY, Superintendent, Leominster, Mass.; BYRON I. COOK, Superintendent, Woonsocket, R. I.; THEODORE H. MCKENZIE, Manager, Southington, Conn.

SECRETARY.

JOHN C. WHITNEY, Water Registrar, Newton, Mass.

TREASURER.

GEORGE E. BATCHELDER, Water Registrar, Worcester, Mass.

SENIOR EDITOR.

JOSEPH E. BEALS, Superintendent, Middleboro, Mass.

JUNIOR EDITOR.

WALTER H. RICHARDS, Superintendent, New London, Conn.

EXECUTIVE COMMITTEE.

LOUIS M. BANCROFT, Superintendent, Reading, Mass.
JOHN C. HASKELL, Superintendent, Lynn, Mass.
A. H. SALISBURY, Superintendent, Lawrence, Mass.

FINANCE COMMITTEE.

A. R. HATHAWAY, Water Registrar, Springfield, Mass.
A. W. F. BROWN, Water Registrar, Fitchburg, Mass.
WILLIAM MCNALLY, Marlboro, Mass.

Mr. Holden moved that the report of the committee be accepted, and that the Secretary be directed to cast the ballot of the Association for the nominees.

At the request of Mr. Cavanagh the motion was divided, and the convention voted to accept the report of the committee.

Mr. Cavanagh then moved that the name of Mr. Robert J. Thomas, of Lowell, be added to the nominations for the Executive Committee. Mr. Salisbury thereupon withdrew his name, which had been presented by the nominating committee, and the convention voted to substitute the name of Mr. Thomas. Then, on motion of Mr. Cavanagh, the Secretary was directed to cast the ballot of the Association for the nominees, and they were declared elected.

President Haskell, on leaving the chair, spoke as follows:

*Gentlemen of the New England Water Works:*

I take pleasure in presenting to you Mr. Willard Kent, whom you have elected to preside over the affairs of this Association for the ensuing year. I trust you will all give to him throughout the year your most hearty support. (Applause.)

President Kent responded as follows:

*Gentlemen:*

I thank you. I assure you I fully appreciate the honor of the presidency of the New England Water Works Association, and I regret that I have not the command of words fittingly to express that appreciation. With your assistance I will endeavor to maintain the present high standing of the Association, so far as it is within my power.

On motion of Mr. Holden the convention adjourned.

## Attendance at Convention held September 8, 9 and 10, 1897.

### Active Members.

Abbott, E. L., Boston, Mass.
Bates, Oren B., Clinton, Mass.
Bancroft, Lewis M., Reading, Mass.
Bisbee, F. E., Auburn, Me.
Batchelder, G. E., Worcester, Mass.
Beals, Jos. E., Middleboro, Mass.
Brooks, E. C., Cambridge, Mass.
Baldwin, Chas. H., Boston, Mass.
Bigelow, James F., Marlboro, Mass.
Bowers, George, Lowell, Mass.
Brackett, Dexter, Boston, Mass.
Bartlett, R. S., Norwich, Conn.
Coggeshall, R. C. P. New Bedford, Mass.
Chace, George F., Taunton, Mass.
Cook, Henry A., Salem, Mass.
Chadbourne, E. J., Wakefield, Mass.
Cook, Byron I., Woonsocket, R. I.
Codd, W. F., Nantucket, Mass.
Cavanagh, John F., Quincy, Mass.
Crowell, Geo. E., Brattleboro, Vt.
Crandall, Geo. K., New London, Conn.
Crawford, J. W., Lowell, Mass.
Chandler, C. E., Norwich, Conn.
Doane, A. O., Newton, Mass.
Daboll, L. E., New London, Conn.
Estabrook, A. F., Leicester, Mass.
Fish, J. B., Scranton, Pa.
Fuller, F. L., Boston, Mass.
French, E. V., Boston, Mass.
Gould, Amos A., Leicester, Mass.
Glover, Albert S., Boston, Mass.
Gilbert, J. C., Whitman, Mass.
Gleason, T. C., Ware, Mass.
Gear, A. S., New York, N. Y.
Huntington, Jas. A., Haverhill, Mass.
Hawley, W. C., Atlantic City, N. J.
Haskell, John C., Lynn, Mass.
Holden, H. G., Nashua, N. H.
Hayes, A. G., Middleboro, Mass.
Hastings, V. C., Concord, N. H.
Hazen, Allen, New York, N. Y.
Hyde, H. N., Newton, Mass.
Harrington, G. W., Wakefield, Mass.
Hammatt, E. A. W., Boston, Mass.
Hill, W. R., Syracuse, N. Y.
Kent, Willard, Narragansett Pier, R. I.
Kuichling, E., Rochester, N. Y.
Kempton, D. B., New Bedford, Mass.
Kingman, Horace, Brockton, Mass.
Kieran, Patrick, Fall River, Mass.
Luther, Wm. J., Attleboro, Mass.

Locke, James W., Brockton, Mass.
Morse, J. W., Natick, Mass.
McKenzie, T. H., Hartford, Conn.
Northrop, F. L., Milford, Mass.
Nichols, Edw. C., Reading, Mass.
Naylor, Thomas, Maynard, Mass.
Perry, F. G., Pawtucket, R. I.
Pollard, W. D., Pottsville, Pa.
Putnam, J. B., Westboro, Mass.
Porter, Dwight, Boston, Mass.
Rogers, H. W., Haverhill, Mass.
Richards, W. H., New London, Conn.
Robertson, W. W., Fall River, Mass.
Sullivan, J. C., Holyoke, Mass.
Smith, H. O., Leicester, Mass.
Sinclair, M. A., Bangor, Me.
Stacy, George A., Marlboro, Mass.
Salisbury, A. H., Lawrence, Mass.
Snow, Edwin W., Somerville, Mass.
Stearns, F. P., Boston, Mass.
Smith, John E., Andover, Mass.
Taylor, L. A., Boston, Mass.
Thomson, John, New York, N. Y.
Tower, D. N., Cohasset, Mass.
Tenney, J. G., Leominster, Mass.
Thomas, R. J., Lowell, Mass.
Whitney, J. C., Newton, Mass.
Welch, J. Alfred, Methuen, Mass.
Winslow, George E., Waltham, Mass.
Wiswall, E. T., West Newton, Mass.
Wallace, E. L., Franklin Falls, N. H.
Walker, Chas. K., Manchester, N. H.
Whipple, G. C., Brooklyn, N. Y.
Watters, Joseph, Fall River, Mass.
Whittemore, W. F., Leicester, Mass.
Zick, W. G., New York, N. Y.

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### Honorary Members.

"Engineering News," of New York, by M. N. Baker.

"Engineering Record," of New York, by H. C. Meyers, Jr., and C. J. Underwood, Jr.

"Fire and Water," of New York, by F. W. Sheppard.

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### Associate Members.

Ashton Valve Co., Boston, Mass., by C. W. Houghton.

Artesian Well Co., Providence, R. I., by Ray S. Baker.

Ashcroft Mfg. Co., Boston, Mass., by J. A. Mitsch.

Blossom, Albert A., Salem, Mass.

Builders' Iron Foundry, Providence, R. I., by C. Clifford.

Chadwick Lead Works, Boston, Mass, by A. H. Brodrick.

Chapman Valve Co., Indian Orchard, Mass., by E. L. Ross.

Coffin Valve Co., Neponset, Mass., by F. E. Adams.

Crosby Steam Gage and Valve Co., Boston, Mass., by Samuel G. Reed.

Deane Steam Pump Co., Holyoke, Mass., by Wm. Burnham, A. M. Pierce and F. H. Hayes.

Eagle Oil and Supply Co., Boston, Mass., by T. J. Babcock and C. N. Goward.

Hersey Mfg. Co., Boston, Mass., by J. E. Safford and J. A. Tilden.

Jenks, Henry F., Pawtucket, R. I.

Kennedy Valve Mfg. Co., New York, N. Y., by M. J. Gilmore.

Lead Lined Iron Pipe Co., Wakefield, Mass., by Thos. E. Dwyer.

National Meter Co., New York City, by John C. Kelley and J. G. Lufkin.

Neptune Meter Co., New York City, by H. H. Kinsey.

Rensselaer Mfg. Co., Troy, N. Y., by Fred S. Bates.

Ross Valve Co., Troy, N. Y., by William Ross.

Anthony P. Smith, Newark, N. J., by W. H. Van Winkle and A. P. Smith.

Sumner & Goodwin Co., Boston, Mass., by F. D. Sumner.

Benj. C. Smith, New York City, by Fred A. Smith.

Thomson Meter Co., Brooklyn, N. Y., by S. D. Higley, E. T. Ivins and Henry C. Folger.

Union Meter Co., Worcester, Mass., by J. P. K. Otis.

Henry R. Worthington, New York City, by O. P. Boller and J. M. Betton.

Wm. Wolfendale, Fall River, Mass.

R. D. Wood & Co., Philadelphia, Pa., by Jesse Garrett.

George Woodman & Co., Boston, Mass., by F. L. Howland.

GUESTS

Ames, C. N., Brockton, Mass.
Bancroft, L. M. Mrs., Reading, Mass.
Beals, Jos. E. Mrs., Middleboro, Mass.
Batchelder, George E. Mrs., Worcester, Mass.
Bacon, James P., Cambridge, Mass.
Burke, M. F., Marlboro, Mass.
Burke, F., Marlboro, Mass.
Bowers, George Mrs., Lowell, Mass.
Bacon, J. P. Mrs., Cambridge, Mass.
Clancey, J. C. Mrs., Syracuse, N. Y.
Codd, W. F. Mrs., Nantucket, Mass.
Carpenter, L. Z., Attleboro, Mass.
Crandall, George K. Mrs., New London, Conn.
Coggeshall, R. C. P. Mrs., New Bedford, Mass.
Clifford, T. C. Mrs., Providence, R. I.
Dean, G. A., Attleboro, Mass.
Daboll, L. E. Mrs., New London, Conn.
Dowd, M. J., Lowell, Mass.
Doane, A. O. Mrs., Newton, Mass.
Estabrooks, A. F. Mrs., Leicester, Mass.
Fish, J. B. Mrs., Scranton, Pa.
Fels, Augnst, Lowell, Mass.
Fels, Mrs., Lowell, Mass.
Fels, Miss, Lowell, Mass.
Fels, Miss, Lowell, Mass.
Faborousky, Miss W., Moscow, Russia.
Glover, Albert S. Mrs., Newton, Mass.
Gould, Amos Mrs., Leicester, Mass.
Gilbert, A. W., Troy, N. Y.
Holden, H. G. Mrs., Nashua, N. H.
Hayes, Maria E. Mrs., Middleboro, Mass.
Hayes, F. H. Mrs., Boston Mass.
Hill, W. R. Mrs., Syracuse, N. Y.
Hawley, C. T., Cambridge, N. Y.
Jenks, Henry F. Mrs., Pawtucket, R. I.
Jenks, Dorothy Miss, Pawtucket, R. I.
Kent, C. A. Mrs., Narragansett Pier, R. I.
Kelley, John C. Mrs., Brooklyn, N. Y.
Kelley, S. T. Miss, Brooklyn, N. Y.
Kelley, E. S. Miss, Brooklyn, N. Y.
Kempton, David B. Mrs., New Bedford, Mass.
Lawrence, W. F., Derby, Conn.
Naylor, Thomas Mrs., Maynard, Mass.
Proctor, C. S. Mrs., Lowell, Mass.
Proctor, H. S., Lowell, Mass.
Pollard, W. D., Pottsville, Pa.
Porter, H. F. J., Bethlehem, Pa.
Plunkett, E. J., Marlboro, Mass.
Porter, Dwight Mrs., Boston, Mass.
Rogers, H. W. Mrs., Haverhill, Mass.
Ross, E. L. Mrs., Indian Orchard, Mass.
Spofford, J. E. Mrs., Boston, Mass.
Simin, Nicholas, Moscow, Russia.
Simin, Olga Miss, Moscow, Russia.
Stacy, G. A. Mrs., Marlboro, Mass.
Salisbury, H. Mrs., Lawrence, Mass.
Thomson, John Mrs., New York, N. Y.
Tower, D. Mrs., Cohasset, Mass.
Tilden, C. F., Cohasset, Mass.
Tilden, J. A. Mrs., Boston, Mass.
Van Winkle, W. H. Mrs., Newark, N. J.
Warde, Charles S., Staten Island, N. Y.
Welch, J. Alfred Mrs., Methuen, Mass.
Wakefield, F. M. Mrs., Syracuse, N. Y.
Whittemore, W. F. Mrs., Leicester, Mass.
Winslow, A. M. Mrs., Waltham, Mass.
Weaver, Frank L., Lowell, Mass.

## LIST OF EXHIBITS AT THE CONVENTION.

In Charge of Mr. Henry F. Jenks, Pawtucket, R. I.

Union Water Meter Co., Worcester, Mass., Water Meters, etc.
Hersey Mfg. Co., Boston, Mass., Water Meters.
Builders' Iron Foundry, Providence, R. I., Venturi Water Meters and castings.
Thomson Meter Co., Brooklyn, N. Y., Water Meters.
Neptune Meter Co., New York City, Water Meters.
Buffalo Meter Co., Buffalo, N. Y., Water Meters.
National Meter Co., New York City, Water Meters.
Coffin Valve Co., Neponset, Mass., Valves, Hydrants, etc.
Ross Valve Co., Troy, N. Y., Pressure Regulating Valves, etc.
Kennedy Valve Mfg. Co., New York City, Valves.
M. J. Drummond, New York City, Testings Plugs and Service Boxes.
B. C. Smith, New York City, Pipe Cutting Machine.
A. P. Smith Mfg. Co., Newark, N. J., Tapping Machine.
Rensselaer Mfg. Co., Troy, N. Y., Valves, etc.
Daniel A. Streeter, Waterbury, Conn., Pipe Plugs.
Eagle Oil and Supply Co., Boston, Mass., Metal Polish.
Henry F. Jenks, Pawtucket, R. I., Drinking Fountain.
Lead-lined Iron Pipe Co., Wakefield, Mass., Lead-lined Pipe.
Crosby Steam Gage and Valve Co., Boston, Steam Gauges and Valves.
H. R. Worthington, New York City, Water Meter and Pumping Eng. Model.
Holly Mfg. Co., Lockport, N. Y., Photographs of Pumping Machinery.
Ashton Valve Co., Boston, Steam Gauges and Valves.
Ashcroft Mfg. Co., New York City, Steam Gauges, etc.
R. D. Wood & Co., Philadelphia, Pa., Drawings of Hydrants, etc.
Deane Steam Pump Co., Holyoke, Mass., Steam Pumps.
Fall River Iron Works, Fall River, Mass., Service Boxes.

## OBITUARY.

RICHARD R. YATES.—Died Sept. 10th, 1896, aged 62 years. Joined the Association, June 18th, 1885.

Mr. Yates was Superintendent of the Northboro, Mass. Water Works for many years.

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CHAS. B. BRUSH.—Died June 3rd, 1897, aged 49 years. Joined the Association, June 16th, 1886.

Mr. Brush graduated as civil engineer from the New York University in which he was for several years a professor of civil engineering. He afterwards devoted himself to a general engineering practice and made a brilliant record as an engineer, being chief engineer of the Hoboken Land and Improvement Co., the North Hudson County Railway Co., the Hoboken Ferry Co., and the Hackensack Water Co. He was a member of many scientific societies, including the American Society of Civil Engineers and the American Water Works Association.

Mr. Brush contributed a valuable paper to this Association on Aeration and Filtration, published in Vol. II., No. 1, p. 71.

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JOSEPH A. LOCKWOOD.—Died August 24th, 1897. Joined the Association, Sept. 14th, 1887.

Mr. Lockwood graduated from Union College as a civil engineer, and had been superintendent of the Yonkers, N. Y. Water Works for 25 years.

# New England Water Works Association Membership Roll.

## SEPTEMBER 1, 1897.

NOTE. — The Secretary requests to be advised of existing errors or change of address from that which appears in the following list.

ACTIVE MEMBERS — RESIDENT AND NON-RESIDENT.

Abbott, Everett L.
Box 2281, Boston, Mass.

Adams, John D.
Superintendent, Provincetown, Mass.

Allen, Charles A.
Civil Engineer, 44 Front street, Rooms 109 and 110, Worcester, Mass.

Allen, Charles F.
Treasurer, Hyde Park, Mass.

Allis, Solon M.
Civil Engineer, 76 Bell Rock street, Malden, Mass.

Amerman, Lemuel.
Manager Water Works, Coal Exchange, Scranton, Pa.

Andrews, Frank A.
Assistant Superintendent, Nashua, N. H.

Armstrong, S. G.
Box 2139, Johannesburg, South Africa.

Ashwell, Wm. H.
Civil Engineer, 76 Home Bank Building, Detroit, Mich.

Babbidge, P. F.
Superintendent, Keene, N. H.

Babcock, Stephen E.
Chief Engineer, Little Falls, N. Y.

Bacot, R. C., Jr.
Superintendent Meter Department, P. O. Box 461, Port Chester, N. Y.

Badger, Frank S.
Engineer's office Locks and Canals, Lowell, Mass.

Bagnell, Richard W.
Superintendent, Plymouth, Mass.

Bailey, E. W.
City Engineer, Somerville, Mass.

Bailey, Frank S.
Assistant City Engineer, Brockton, Mass.

Bailey, George I.
Superintendent, 61 State street, Albany, N. Y.

Baldwin, Charles H.
Box 2410, or 159 Franklin street, Boston, Mass.

Baldwin, Richard.
Proprietor Water Works, Terryville, Conn.

Bancroft, Arthur G.
Civil Engineer, Box 506, Reading, Mass.

Bancroft, Lewis M.
Superintendent, Reading, Mass.

Barbour, Frank A.
Civil Engineer, P. O. Box 1235, Brockton, Mass.

Barns, Everett.
Superintendent, Westerly, R. I.

Barrett, Albert P.
Woburn, Mass.

Barrus, George H.
Consulting Steam Engineer, 95 Milk street, Boston, Mass.

Bartlett, Charles H.
Civil Engineer, 852 Elm street, Manchester, N. H.

Bartlett, R. S.
Superintendent, Norwich, Conn.

Bassett, Carroll, Ph.
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Walker, John.
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Warde, John S.
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Warren, H. A.
Superintendent, St. Albans, Vt.

Watters, Joseph.
Water Commissioner, Fall River, Mass.

Webster, F. P.
Superintendent, Lakeport, N. H.

Welch, J. Alfred.
Superintendent, Methuen, Mass.

Wescott, George P.
Treasurer Portland Water Co., Portland, Me.

Weston, Robert S.
First Assistant Chemist Louisville Water Co., Louisville, Ky.

Wheeler, Elbert.
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Wheeler, Warren B.
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Superintendent Electric Light and Water Depts., North Attleboro, Mass.

Whittier, Herbert F.
253 Jackson street, Lawrence, Mass.

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Superintendent and Engineer, Henderson, Ky.

Wilcox, William C.
Waltham, Mass.

Wilde, George E.
Duxbury, Mass.

Wilder, Frederick W.
Treasurer Aqueduct Co., Woodstock, Vt.

Williams, G. S.
Engineer Water Dept., Detroit, Mich.

Williams, William F.
City Engineer, New Bedford, Mass.

Winship, Horace B.
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Winslow, George E.
Waltham, Mass.

Winslow, S. J.
Superintendent, Pittsfield, N. H.

Wiswall, E. T.
Water Commissioner, West Newton, Mass.

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Executive Engineer Street Department, Room 47, City Hall, Boston, Mass.

Woodruff, Timothy.
Superintendent, Bridgeton, N. J.

Woods, Henry D.
City Engineer, West Newton, Mass.

Worthington, E., Jr.
Civil Engineer, Dedham, Mass.

Wright, George W.
Chief Engineer, Box 426, Norfolk, Va.

Wright, Luther C.
Superintendent, Northampton, Mass.

Yorston, W. G.
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Zick, W. G.
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HONORARY MEMBERS.

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Engineering News, Tribune Building, New York City.

Gale, James M.
Engineer-in-Chief, Loch Katrine Water Works, Glasgow, Scotland.

Jones, E. R.
561 Shawmut avenue, Boston, Mass.

Meyer, Henry C.
The Engineering Record, 100 William street, New York City.

Shepperd, F. W.
Fire and Water, Box 128, 93 and 97 William street, New York City.

ASSOCIATE MEMBERS.

Allis, The Edward P. Co.
"High Duty Pumping Engines," Milwaukee, Wis.

Ashton Valve Co.
"Water Relief Valves," 271 Franklin street, Boston, Mass

Betton, James M.
Agent H. R. Worthington, 70 Kilby street, Boston, Mass.

Blake, The George F. Mfg. Co.
"Pumping Engines," 95 and 97 Liberty street, New York. City.

Boston Lead Mfg. Co.
162 Congress street, Boston, Mass.

Brandt, Randolph.
"Selden Patent Packing," 38 Cortlandt street, New York City.

Brewster, H. M. (E. Stebbins Mfg. Co.)
"Brass Goods," Brightwood P. O., Springfield, Mass.

Chadwick Lead Works.
176 to 184 High street, Boston, Mass.

Chapman Valve Mfg. Co.
"Valves and Hydrants," Indian Orchard, Mass.

Coffin Valve Co.
"Valves and Hydrants," Neponset, Boston, Mass.

Crosby Steam Gage and Valve Co.
"Gages, Valves, etc.," Robert Pirie, Manager, N. E. Sales Dept., 93 Oliver street, Boston, Mass.

Davidson, M. T.
"Steam Pumps," 43 and 53 Keap street, Brooklyn, N. Y.

Deane Steam Pump Co.
"Steam pumps and pumping machinery," Holyoke, Mass.

Dibble, F. J.
"Electric Indicators," Peabody, Mass.

Drummond, M. J.
"Cast Iron Pipe," 192 Broadway, Corbin Building, New York City.

Dunne, George C.
Manager Portland Stoneware Co., 42 Oliver street, Boston, Mass.

Eagle Oil and Supply Co.
100 Broad street, Boston, Mass.

Fairbanks Co., The.
"Valves," 77 and 79 Milk street, Boston, Mass.

Frost & Adams Co.
"Architects' Supplies," 37 Cornhill, Boston, Mass.

Garlock Packing Co.
"Packing," 12 Pearl street, Boston, Mass.

Gallison, William H. Co.
"Engineers Supplies, Pipe, etc.," 36 Oliver street, Boston, Mass.

General Manufacturing Co.
"Pumping Engines and Hydraulic Specialties," 417 Franklin avenue, Brooklyn, N. Y.

Gilchrist, George E.
"Pipes and Fittings," 106 High, corner Congress street, Boston, Mass.

Giles, Jason.
Chapman Valve Mfg. Co., "Valves and Hydrants," Indian Orchard, Mass.

Gould, H. F.
Ludlow Water Co., 185 Devonshire street, Boston, Mass.

Goulds Mfg. Co. The.
"Engines," 236 Congress street, Boston, Mass.

Harlow, Mellen S.
"Pohlé Air Lift Pump," "Ingersoll-Sergeant Drill Co.," 201 Congress street, Boston, Mass.

Hawkins, F. B.
"Cast Iron Pipe," 29 Broadway, New York City.

Helmer, W. K.
Agent Holly Mfg. Co., Lockport, N. Y.

Hersey Manufacturing Co.
"Meters," South Boston, Mass.

Holly Manufacturing Co.
"Pumping Machinery," Lockport, N. Y.

Hydraulic Construction Co., The.
"Well Plants," William D'H. Washington, General Manager, Rooms 46 and 47, 145 Broadway, New York City.

Jackson & Woodin Mfg. Co.
"Cast Iron Pipe," Berwick, Penn.

Jenkins Bros.
"Valves and Packing," 17 Pearl street, Boston, Mass.

Jenks, Henry F.
"Drinking Fountains," Pawtucket, R. I.

Ludlow Valve Mfg. Co.
"Valves and Hydrants," Troy, N. Y.

Lynch, John E.
Proprietor "E. Hodge & Co., Stand Pipes," East Boston, Mass.

McNeal Pipe and Foundry Co., The.
"Cast Iron Pipe," Burlington, N. J.

Michigan Brass and Iron Works.
"Valves, Hydrants and Brass Goods, Detroit. Mich."

Moore, Charles A.
"Engines, Boilers and Supplies," 111 Liberty street, New York City.

Morison, Samuel L.
The Morison-Jewell Filtration Company, 26 So. 15th street, Philadelphia, Penn.

Morris, I. P. Co.
"Pumping Engines," cor. Beach and Ball streets, Philadelphia, Penn.

Mueller, H. Mfg. Co.
"Water Works Supplies," Decatur, Ill.

National Lead Co. (Boston Branch).
234 Congress street, Boston, Mass.

National Meter Co.
"Meters," 118 Chambers street, New York City.

National Tube Works Co.
"Pipe and Fittings," McKeesport, Pa. Address P. W. French, Secretary, 70 Federal street, Boston, Mass.

Neptune Meter Co.
"Trident Water Meters," 253 Broadway, New York City.

New York Filter Co.
"Filters," 145 Broadway, New York City.

Norwood Engineering Co.
"Hydrants, etc.," Florence, Mass.

Nye, Walter B.
"Warren Filter," 220 Devonshire street, Boston, Mass.

Peck Bros & Co.
"Water Works Supplies, 65 Oliver street, Boston; Mass.

Perrin, Seamans & Co.
"Construction Tools and Supplies," 57 Oliver street, Boston, Mass.

Pittsburg Meter Co.
"Water Meters," Pittsburg, Pa.

Ranton, William J.
1300 1st North street, Syracuse, N. Y.

Rensselaer Mfg. Co.
"Valves and Water Gates," Troy, N. Y.

Roberts, C. E.
Hartford Steam Boiler Inspection and Insurance Co., 125 Milk street, Telephone Building, Boston, Mass.

Robertson, R. A.
Treasurer Builders' Iron Foundry, P. O. Box 218, Providence, R. I.

Rose Valve Co.
"Valves," Troy, N. Y.

Ryder, N. F.
"Varnish," Middleboro, Mass.

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## ERRATA.

In the diagram on Page 113 for 1885 *read* 1895.